SOUTH CAROLINA ELECTRIC & GAS

SCANA®
POWER FOR LIVING

CLOSURE PLAN

FOR THE

WATEREE STATION
CLASS III LANDFILL

RICHLAND COUNTY, SOUTH CAROLINA

SEPTEMBER 2016

SOUTH CAROLINA
GARRETT AND MOORE, INC.
No. C3371
CERTIFICATE OF AUTHORIZATION

GARRETT & MOORE
Engineering for the Power and Waste Industries

SOUTH CAROLINA
REGISTERED PROFESSIONAL ENGINEER
22411
9/22/16
J. STEFAN BRAY

1 OVERVIEW

The EPA Administrator, Gina McCarthy, signed the Disposal of Coal Combustion Residuals from Electric Utilities final rule on December 19, 2014, and it was published in the Federal Register (FR) on April 17, 2015. The regulations provide a comprehensive set of requirements for the safe disposal of coal combustion residuals (CCRs), commonly known as coal ash, from coal-fired power plants. The rule will be administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], using the Subtitle D approach.

South Carolina Electric & Gas (SCE&G) is subject to the CCR Rule. Based on SCE&G's review of the rule, the **Class Three Landfill** at **SCE&G Wateree Station** has been determined to be an existing CCR landfill subject to the CCR rule requirements.

2 PURPOSE

The purpose of this report is to document that the Wateree Station Class Three Landfill Closure Plan meets the requirements of CCR rule §257.102 – *Written Closure Plan.*

3 APPLICABLE REGULATIONS

CCR rule §257.102 – *Written Closure Plan* states the following:

(b) Written closure plan. (1) Content of the plan. The owner or operator of a CCR unit must prepare a written closure plan that describes the steps necessary to close the CCR unit at any point during the active life of the CCR unit consistent with recognized and generally accepted good engineering practices. The written closure Plan must include, at a minimum, the information specified in paragraphs (b)(1)(i) through (vi) of this section.

(i) A narrative description of how the CCR unit will be closed in accordance with this section.

(ii) If closure of the CCR unit will be accomplished through removal of CCR from the CCR unit, a description of the procedures to remove the CCR and decontaminate the CCR unit in accordance with paragraph (c) of this section.

(iii) If closure of the CCR unit will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with paragraph (d) of this section, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in paragraph (d) of this section.

(iv) An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR unit.

(v) An estimate of the largest area of the CCR unit ever requiring a final cover as required by paragraph (d) of this section at any time during the CCR unit's active life.

(vi) A schedule for completing all activities necessary to satisfy the closure criteria in this section, including an estimate of the year in which all closure activities for the CCR unit will be completed. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR unit, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, the dewatering and stabilization phases of CCR surface impoundment closure, or installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR unit closure. When preparing the written closure plan, if the owner or operator of a CCR unit estimates that the time required to complete closure will exceed the timeframes specified in paragraph (f)(1) of this section, the written closure plan must include the site-specific information, factors and considerations that would support any time extension sought under paragraph (f)(2) of this section.

The closure of the Class Three Landfill is to be accomplished by leaving CCR in place, therefore per (b)(1)(iii) as stated above, the closure plan must also discuss how the final cover system will achieve the performance standards specified in paragraph 257.102 (d), which states:

(d) Closure performance standard when leaving CCR in place. (1) The owner or operator of a CCR unit must ensure that, at a minimum, the CCR unit is closed in a manner that will:

(i) Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;

(ii) Preclude the probability of future impoundment of water, sediment, or slurry;

(iii) Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;

(iv) Minimize the need for further maintenance of the CCR unit; and

(v) Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

4 CLASS THREE LANDFILL DESCRIPTION

Wateree Station is coal-fired electric generation plant located along the Wateree River near Eastover, Richland County, South Carolina. The Class Three landfill associated with the plant is entirely located within the property boundaries of Wateree Station. The landfill facility is comprised of 18 landfill cells, planned for development in multiple phases and encompassing a total of approximately 141 lined acres.

The active disposal unit was constructed in accordance with the construction permit (permit # LF3-00026) issued from the South Carolina Department of Health and Environmental Control (DHEC) on September 30, 2008, modified on June 28, 2013. Cells 1 through 5, encompassing approximately 34-acres, were placed into operation in accordance with an operation approval issued by DHEC on April 21, 2010. Cells 6 through 9, encompassing an additional approximate 37-acres, were placed into operation in accordance with an operation approval issued by DHEC on February 2, 2015.

5 CLOSURE PLAN

A Closure Plan has been prepared and regulatory approved for the closure of the Class Three Landfill, which includes the installation of a final cover system over the in-place CCR. The Closure Plan was approved by SCDHEC Bureau of Land and Waste Management in June 2013 (solid waste permit # LF3-00026). A copy of the approved Closure Plan is presented in Attachment 1.

The Closure Plan (attached, to include Drawings and CQA Plan documents referenced in Closure Plan) includes a narrative description of how the landfill will be closed, an estimate of the maximum inventory of CCR on-site, and a schedule for completing all activities necessary to satisfy the closure, in satisfaction of the requirements of §257.102 (b)(1) paragraphs (i), (iv) and (vi), respectively.

The Closure plan also includes a description of the final cover system, as well as a description of the materials to be used in the final cover system and the methods and procedures required to install the final cover system. A discussion how the final cover system achieves the performance standards specified in paragraph 257.102 (d) is presented in the Closure Plan Addendum, which is presented in Attachment 2. The discussion presented in this paragraph inclusive of the Closure Plan Addendum satisfies the requirement of §257.102 (b)(1) paragraphs (iii).

The requirements of paragraph §257.102 (b)(1)(ii) is not applicable as it pertains to closure involving the removal of CCR from the CCR unit.

8 CONCLUSION

Based on the discussions above, the Wateree Station Class Three Landfill Closure Plan meets the requirements of CCR rule §257.102 – *Written Closure Plan.*

ATTACHMENT 1

CLOSURE PLAN

CLOSURE PLAN

SECTION 8

8.1 Closure Plan

Regulation 61-107.19 of the Solid Waste Management Regulations requires a permittee of a Class Three Landfill to prepare a closure plan that addresses the criteria for closure defined in Section 258.60. This closure plan describes the steps necessary to close the Wateree Class Three Landfill at any point during the active life in accordance with the requirements of that Section, as applicable. Partial closure refers to the closure of a portion of phase of the landfill; final closure is achieved upon closure of the entire landfill.

This plan addresses the objectives and implementation of closure, including minimizing the exposure of the waste fill and generation of leachate. Specifically, this closure plan provides a description of the final cover (cap) design, establishes a preliminary plan for closure and cost estimate to construct the final closure cap.

8.2 Final Cover System

The final cover (cap) design includes two options. The cap is designed to minimize stormwater infiltration through the closed landfill and to resist erosive forces. The cap system consists of an erosion layer, drainage layer, and barrier layer. The multi-layered cap system provides a permeability less than or equal to the bottom liner system of the landfill or a permeability no greater than 1 x 10^{-5} cm/sec, an erosion layer to minimize erosion and support vegetation and stormwater management features to convey stormwater.

The cap system will consist of the following layers (listed from top to bottom):

OPTION 1

- 6-inch Drainage and Erosion Layer consisting of soil capable of supporting native plant growth;
- 18-inch thick Drainage and Erosion Layer
- Geocomposite Drainage Net consisting of double-sided heat-bonded geocomposite. The geocomposite is designed to horizontally drain storm water that has percolated through the Drainage & Erosion Soil Layers, thus minimizing infiltration; and
- A Flexible Membrane Liner (FML) consisting of a 40-mil Textured Linear Low Density Polyethylene (LLDPE) geomembrane
- 18-inch thick Infiltration Layer consisting of low permeable soil (1 x 10^{-5} cm/sec)

OPTION 2

- 6-inch Drainage and Erosion Layer consisting of soil capable of supporting native plant growth;
- 36-inch Drainage and Erosion Layer
- Geocomposite Drainage Net consisting of double-sided heat-bonded geocomposite. The geocomposite is designed to horizontally drain storm water that has percolated through the Drainage & Erosion Soil Layers, thus minimizing infiltration; and
- A Flexible Membrane Liner (FML) consisting of a 40-mil Textured Linear Low Density Polyethylene (LLDPE) geomembrane

The final cover system shall promote positive drainage with final design grades of the top surface not less than 3-percent. The side slopes without turf reinforcement matting will not

exceed three horizontal feet to one vertical foot (3:1). *Refer to the Permit Drawings for details of the proposed final cover (cap) system and final grading plan.*

Differential settlement is not anticipated to occur with this waste mass.

A description of the materials to be used in the final cover system and the methods and procedures required to install the final cover system can be found in *Section 5 – Construction Quality Assurance (CQA) Plan*, of the permit application.

8.3 Landfill Gas Management System

The waste materials disposed in the facility have little or no organic element and is not anticipated to produce gas resulting from decomposition. The closure plan does not include a gas management system.

8.4 Estimate of Largest Area Requiring Final Cover

The landfill closure area is 128.2 acres. Closure of the facility will be performed in phases based on the filling sequence of the landfill. It is anticipated that the largest area requiring final cover at any time during the active life of the landfill will be approximately 128.2 acres.

8.5 Estimate of Maximum Inventory of Waste

The proposed Class Three Landfill is estimated to provide 17,619,262 cubic yards of capacity. The waste disposed at the facility is anticipated to yield near a 100% utilization factor and a density of 2,000 pounds per cubic yard. Nominal volumes of soil are required during operations. For the purpose of addressing this item, conservatively the maximum amount of waste that is expected to be landfilled at the Wateree Station Class Three Landfill is approximately 17,619,262 tons waste.

8.6 Landfill Closure Sequence

Closure activities may be initiated in phases according to the sequence of filling. Partial closure events will occur after a phase or significant portion of the landfill has reached the final grades (waste) indicated on the Drawings. At capacity or once the last remaining active area achieves final grades (waste), closure activities for final closure of the facility will begin. The steps for implementing the closure process are described in the following subsections. The steps are the same for partial closure and final closure.

8.7 Determination of Closure Area

SCE&G will determine the location and acreage of areas to be closed. Closure construction will not be initiated until final grades (waste) of an adequate sized area are achieved. The facility will be surveyed periodically to determine the status and estimate the landfill area that has reached final grades. SCE&G will determine the number of closure events and size of a particular closure event for the facility.

For final closure, closure activities shall begin no later than 30 days after the date on which the Class Three Landfill receives the known final receipt of wastes; or if capacity is remaining and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Department if the permittee, SCE&G demonstrates that the landfill has the capacity to receive additional wastes and the permittee has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the unclosed landfill.

8.8 Notification of Intent to Initiate Closure

Once SCE&G has determined that an area will be closed, a Notice of Intent shall be submitted to the Department to include a schedule outlining the planned closure activities. A description of the area to be closed, acreage, and schedule of the closure activities will be provided.

8.9 Closure Schedule

Once an area has been determined to be closed, SCE&G will prepare a schedule for closure activities. Closure of the subject area must be completed within 180 days following of beginning closure activities. Extensions of the closure event period may be granted by the Department if the permittee, SCE&G demonstrates that closure will take longer than 180 days and they have taken and will continue to take all steps to prevent threats to human health and the environment from the unclosed landfill

8.10 Construction Contract Documents

Construction plans and documents will be prepared for each respective closure event. SCE&G will use the documents for bidding and construction of the closure project. The quantity of soils and materials required for the project will be estimated; cost estimates will be generated for each closure event.

8.11 Final Cover Soil

The material to be used for construction of the closure cap system will be obtained from on-site stockpile areas or borrow areas and/or off-site borrow sources. The source or sources will be selected based on ability to provide material conforming to project specifications, availability of the required volumes and proximity to the site. This may be determined prior to a closure event or during bidding of the project.

The estimated volume of the soil required for final closure of the landfill is 725,000 cubic yards.

8.12 Certification of Closure

Following each closure event, SCE&G shall submit to the Department for approval, certification signed by a South Carolina registered professional engineer, verifying that closure has been completed in accordance with the closure plan. A copy of this certification shall be placed in the operating record.

Procedures for certification of closure construction may be found in *Section 6 – Construction Quality Assurance Plan* of this Application, and the associated specifications sections therein.

8.13 Record Notation to Deed

Within 30 days of the Department's issuance of final closure approval of the landfill, SCE&G shall record with the appropriate Register of Deeds, a notation in the record of ownership of the property - or some other instrument which is normally examined during title search - that will in perpetuity notify any potential purchaser of the property that the land or a portion thereof was used for the disposal of solid waste. This notice shall define the final boundaries of the waste disposal area including the latitude and longitude, identify the type, location, and quantities of solid waste disposed on the property, and advise potential owners of the property that there are land use restrictions.

8.14 Financial Assurance

SCE&G is required to provide financial assurance for the costs to close the largest active area ever requiring final cover at any time during the life of the facility. The cost estimate will be

annually adjusted to account for inflation and any changes in conditions at the facility or in the design. If conditions call for a reduction in the amount to be financially assured, approval of the Department must be obtained prior to officially reducing the amount.

An Engineer's Opinion of Cost for closure of the landfill is provided in Appendix A (Table 8-1) of this Section. The cost estimate is based on the area discussed in paragraph 8.4.

8.15 Revisions to the Plan

If for any reason changes occur, requiring deviations from the approved closure plan or final cover (cap) design, the closure plan will be revised and submitted to the Department for review and approval prior to implementation.

Any updates to the closure plan, and any monitoring, testing, or analytical data as required by Sections 258.60, shall be maintained in the Operating Record.

SECTION 8 – APPENDIX A

Engineer's Opinion of Costs for Closure

TABLE 8-1

CLOSURE COST ESTIMATE
WATEREE STATION CLASS THREE LANDFILL

Item Number	Description	Estimated Quantity	Unit	Unit Price	Extended Total
1	Bonds, Insurance, Mobilization and Demobilization	128.2	AC	$ 5,000.00	$ 641,000.00
2	Temporary Stormwater Management	128.2	AC	$ 5,000.00	$ 641,000.00
3	Strip and Fine Grade Ex. Intermediate Cover Soil	620,488	SY	$ 1.25	$ 775,610.00
4	Remove / Replace Unsuitable Materials	12,820	CY	$ 15.00	$ 192,300.00
5	40-mil Textured LLDPE Flexible Membrane Liner	620,488	SY	$ 4.00	$ 2,481,952.00
6	Geocomposite Drainage Net	620,488	SY	$ 5.00	$ 3,102,440.00
7	42-Inch-Thick Drainage and Erosion Layer	620,488	SY	$ 8.00	$ 4,963,904.00
8	Liner System Bootless Pipe Penetrations	60	EA	$ 2,500.00	$ 150,000.00
9	Composite Toe Drain	9,700	LF	$ 65.00	$ 630,500.00
10	Terrace Berms - Complete	36,969	LF	$ 75.00	$ 2,772,675.00
11	Terrace Berm HDPE Inlet Structure and Slope Drain Pipe Connector	13	EA	$ 12,000.00	$ 156,000.00
12	HDPE Pipe Slope Drain Pipe	6,800	LF	$ 35.00	$ 238,000.00
13	Slope Drain Outlet Structure	13	EA	$ 5,000.00	$ 65,000.00
14	Slope Drain Outlet Structure Rip Rap (Class C) Energy Dissipators	13	EA	$ 3,500.00	$ 45,500.00
15	Seeding & Mulching	128.2	AC	$ 1,800.00	$ 230,760.00
16	Erosion Control Matting	620,488	SY	$ 1.75	$ 1,085,854.00
17	Miscellaneous Work & Cleanup	128.2	AC	$ 6,000.00	$ 769,200.00
18	Engineering and CQA Services	128.2	AC	$ 13,500.00	$ 1,730,700.00
19	5% Contingency of Above Items	1.0	LS	$ 1,033,619.75	$ 1,033,619.75
			Total Closure Cost		**$ 21,706,014.75**

CLOSURE PLAN REFERENCED DRAWINGS

SOUTH CAROLINA ELECTRIC & GAS
WATEREE STATION
CLASS THREE LANDFILL
CELLS 6 - 18
PERMIT MODIFICATION DRAWINGS

LOCATION MAP

INDEX OF DRAWINGS

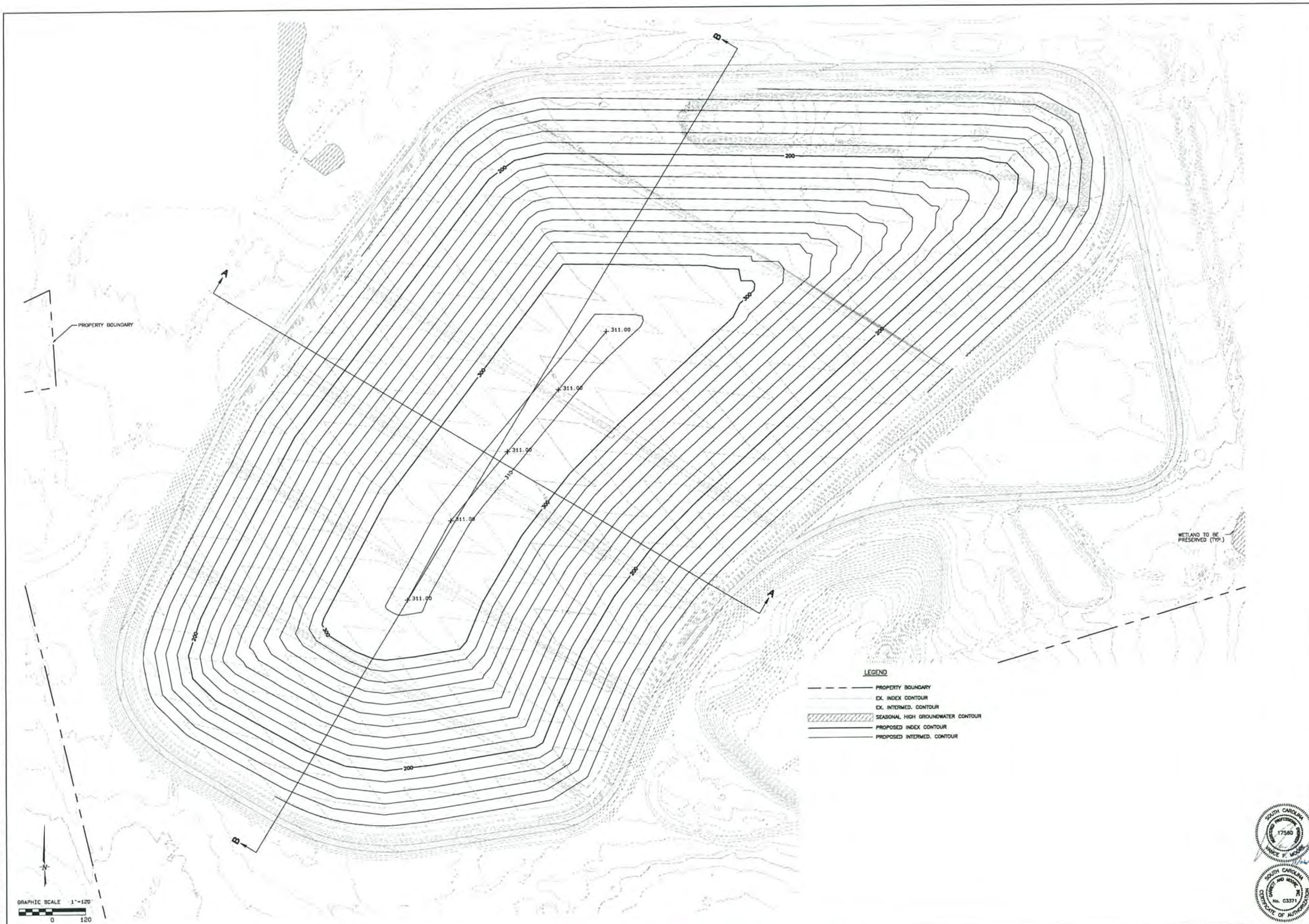
NOVEMBER 2012

PREPARED BY:

GARRETT & MOORE

Engineering for the Power and Waste Industries

1258 BENSON ROAD
GARNER, NORTH CAROLINA 27529
TEL: 919 - 792 - 1900 FAX: 866 - 311 - 7206
www.garrett-moore.com



REVISION	DATE
1)	
2)	
3)	
4)	

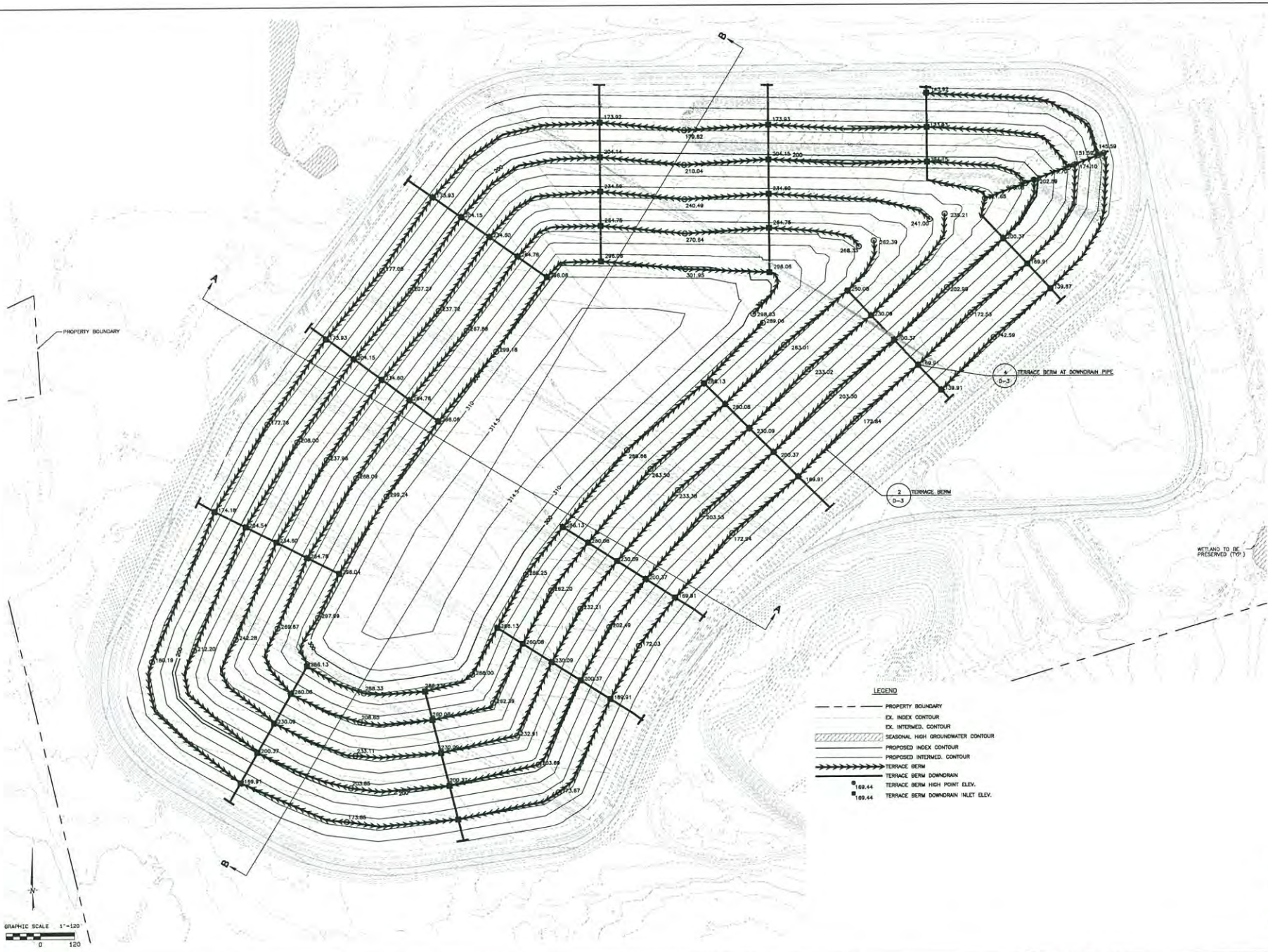
GARRETT & MOORE
Engineering for the Power and Waste Industries

1999 BENSON ROAD
GARNER, N.C. 27529
TEL: 919 - 766 - 1600
FAX: 866 - 211 - 7505
www.garrett-moore.com

SCE&G - WATEREE STATION - CLASS THREE LANDFILL
CELLS 6-18 PERMIT MODIFICATION DRAWINGS

TOP OF WASTE GRADES

SHEET
5



REVISION	DATE
1)	
2)	
3)	
4)	

GARRETT & MOORE
Engineering for the Power and Waste Industries

SCE&G - WATEREE STATION - CLASS THREE LANDFILL CELLS 6-18 PERMIT MODIFICATION DRAWINGS

CLOSURE PLAN/ TOP OF FINAL COVER GRADES

SHEET 6

CLOSURE PLAN REFERENCED CQA PLAN

CONSTRUCTION QUALITY ASSURANCE REPORT

SECTION 6

APPENDIX

Quality Assurance Plan and Technical Specifications

6.0 Quality Assurance / Quality Control Report

Subpart H.3 (13) describes as part of a Class Three Landfill Permit Application the applicant is required to: *Include a Quality Assurance/Quality Control (QA/QC) Report prepared in accordance with accepted QA/QC practices. This report shall address the construction requirements set forth in this Part for each phase of construction and shall include, but not be limited to:*

(a) A delineation of the QA/QC management organization, including the chain of command of the QA/QC inspectors and contractors;

(b) A description of the required level of experience and training for the contractor, his crew, and QA/QC inspectors for every major phase of construction, in sufficient detail to demonstrate that the installation methods and procedures required in this document are properly implemented; and,

(c) A description of the QA/QC testing protocols for every major phase of construction, including, but not limited to, the base liner system, leachate collection system, and final cover system. The QA/QC testing protocol shall include at a minimum: the frequency of inspection; field testing; sampling for laboratory testing, the sampling and field testing procedures and equipment to be utilized; the calibration of field testing equipment, the frequency of performance audits; the sampling size; the soils or geotechnical laboratory to be used; the laboratory procedures to be utilized; the calibration of laboratory equipment and QA/QC of laboratory procedures, the limits for test failure; and, a description of the corrective procedures to be used upon test failure;

6.1 QA/QC Management Organization

The CQA Plan addresses the construction requirements set forth for each phase of construction and is presented in the construction Technical Specifications such that the Plan can be incorporated in the construction plans and specifications for each construction event. The CQA Plan is presented in Appendix A, Section 01040 of this Section and includes Contractor Qualifications, Quality Assurance and Quality Control Personnel Qualifications.

Technical Specifications for each major construction activity are also included in Appendix A of this Section. Quality Assurance and Quality Control testing protocols are detailed in each respective specification section.

6.2 Contingency Plan

Subpart H.5.b.(13) requires a Contingency Plan that includes: *an organized, planned and coordinated, technically and financially feasible course of action to be taken in responding to contingencies during the construction and operation of the landfill. The plan shall provide a description of the criteria to be utilized in evaluating deficiencies, and selecting and implementing corrective actions. The plan shall, at a minimum, address:*

(a) Procedures for responding to deficiencies during the construction phase resulting from circumstances including, but not limited to, inclement weather, defective materials or construction inconsistent with specifications as demonstrated by quality control testing;

Protocols for protection of the work and procedures for corrective action are included in the CQA Plan and each respective specification section, as appropriate.

SECTION 6 – APPENDIX A

Construction Quality Assurance Plan and
Technical Specifications

SOUTH CAROLINA ELECTRIC & GAS

CONSTRUCTION QUALITY ASSURANCE PLAN AND TECHNICAL SPECIFICATIONS

FOR

WATEREE STATION
CLASS THREE LANDFILL

RICHLAND COUNTY, SC

OCTOBER 2012

SCE&G WATEREE STATION
CLASS THREE LANDFILL

CQA PLAN AND TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

END OF SECTION

SECTION 01040

CONSTRUCTION QUALITY ASSURANCE / QUALITY CONTROL PLAN (CQA PLAN)

PART 1 GENERAL

1.1 SUMMARY

This section addresses the Construction Quality Assurance/Quality Control Plan (CQA Plan) for the installation of critical items of work associated with this project.

The CQA Plan is a joint effort between the Contractor and the Owner. This section presents the principals and practices to be implemented during construction. Additional quality assurance/quality control measures are stated in the individual specifications sections contained in the appendix of the plan.

1.2 MEASUREMENT AND PAYMENT

Work required for the CQA Plan by the Contract Documents shall not be measured for direct payment. All costs in connection with this work shall be reflected and included in the unit price for the items to which they pertain.

1.3 ELEMENTS OF THE CQA PLAN

Responsibility and Authority – The responsibility and authority of organizations and key personnel (by title) involved in permitting, designing, and constructing the landfill facility.

Inspection Activities – The observations and tests that will be used to ensure that the construction or installation meets or exceeds all design criteria, plans, specifications, and regulations for each landfill component of the construction project. Inspection activities are discussed in sections for each specific work item that is presented in the appendix of the plan.

Sampling Strategies – The sampling activities, sample size, methods for determining sample locations, frequency of sampling, acceptance and rejection criteria, and methods for ensuring that corrective measures are implemented as addressed in the design criteria, plans, specifications, and regulations. Sampling strategies are discussed in section for each specific work item.

Documentation – Reporting requirements for CQA activities including daily field reports, inspection data sheets, problem identification and corrective measures reports, acceptance reports and final documentation.

1.4 CONSTRUCTION QUALITY ASSURANCE AND CONSTRUCTION QUALITY CONTROL

In the context of this CQA Plan, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance refers to the means and methods employed by the Owner to assure conformity of construction of the landfill and landfill final cover system (compacted soil liner, geomembrane liners, protective cover layers, etc.) and their materials, workmanship and installation with this CQA/CQC Plan, Contract Drawings, and the Specifications. CQA is provided by the CQA Officer as a representative of the Owner and independent from construction and installation.

Construction Quality Control refers to those actions taken by manufacturers, installers, Quality Control Agency, and/or Contractor to ensure that the materials and the workmanship meet the requirements of this CQA/CQC Plan and the Specifications. CQC is provided by the Contractor's CQC Engineer.

1.5 DEFINITION, RESPONSIBILITIES, AND QUALIFICATIONS OF PARTIES

1.5.1 General

The principal parties involved in the CQA Plan for the landfill facility include the Owner, Permitting Agency, Engineer, CQA Officer, Quality Assurance Laboratory, QA Resident Project Representative, Contractor, Quality Control firm, Quality Control Laboratory, Contractor's Surveyor, Manufacturers, and Installers. The general responsibilities, authorities and qualifications, as applicable, of each of these parties are described in the following paragraphs. The responsibility and/or authority of a given party may be modified or expanded as dictated by specific project needs during the Pre-construction Conference. The changes shall be incorporated into the CQA Plan prior to construction.

1.5.2 Owner

1.5.2.1 Definition

The Owner is South Carolina Electric & Gas (SCE&G)

1.5.2.2 Responsibilities

The Owner is responsible for the design, construction, and operation of the landfill facility. This responsibility includes compliance with the permit and submission of CQA documentation demonstrating that the facility was constructed in accordance with the permit documents and the design plans and specifications.

The Owner has the authority to select and dismiss parties charged with design, CQA, and construction activities. The Owner also has the authority to accept or reject design plans and specifications, CQA plans, reports and recommendations of the CQA Officer or CQC Officer, and the materials and workmanship of Contractors.

1.5.3 Permitting Agency

1.5.3.1 Definition

The Permitting Agency is the South Carolina Department of Health and Environmental Control, Division of Mining and Solid Waste Management (SCDHEC or the Department).

1.5.3.2 Responsibilities

As construction progresses, DHEC has the responsibility and authority to review and accept or reject design revisions or requests for variance submitted by the Owner.

1.5.4 Engineer

1.5.4.1 Definition

The Engineer is Garrett and Moore, Inc., who was retained by the Owner to perform the engineering design and prepare the associated drawings and specifications.

1.5.4.2 Responsibilities

The Engineer is responsible for approving all design and specification changes, clarifying the design, reviewing and approving shop drawings, and other tasks as required during construction. The Engineer is also responsible for preparing the permit documents for acceptance by the Permitting Agency. The permit documents include forms, narratives, CQA Plan, design plans, and specifications that support construction and closure of the landfill. During construction, the Engineer may be requested to clarify inconsistencies or contradictions in the construction and contract documents or the CQA Plan.

During construction, the Engineer may approve substantive changes to the design plans or specifications of the facility. Substantive changes may require DHEC notification and/or approval prior to making any changes in the field. Substantive changes include any changes that modify or impact the technical basis for any engineered component of the facility design.

1.5.4.3 Qualifications

The Engineer shall be a Professional Engineer licensed by the State of South Carolina. The Engineer shall be familiar with general earthwork, low permeability soils and soil liners, geosynthetics including detailed design methods and procedures, and all applicable regulatory requirements.

1.5.5 CQA Officer

The CQA Officer is an entity, independent of the Contractor, responsible for observing, testing, and documenting activities related to the construction quality assurance of the project. The CQA Officer is also responsible for issuing a certification report, sealed by a Professional Engineer registered in the State of South Carolina. The CQA Officer may be the Engineer.

1.5.5.1 Definition

The CQA Officer is a company or individual responsible for observing and documenting activities related to the permit documents and the CQA Plan. The CQA Officer is represented on-site by supporting CQA monitoring personnel as appropriate.

1.5.5.2 Responsibilities

The CQA Officer will report directly to the Engineer during construction. In general, the responsibilities and authorities of the CQA Officer include:

- Complete understanding of the permit documents, design plans, and specifications in relation to all aspects of the CQA Plan;
- Scheduling, coordinating and performing CQA activities;
- Performing independent on-site observation of the work in progress to assess compliance with the CQA Plan, permit documents, design plans, and specifications;
- Recognizing and reporting deviations from the CQA Plan, permit documents, design plans, and/or specifications to the Engineer. Secure documents from the Engineer, which approve the changes;
- Verifying that the testing equipment meets testing and calibration requirements, and that tests are conducted according to standardized procedures defined in the CQA Plan or the specifications;
- Verifying that the raw data are properly recorded, validated, reduced, summarized, and interpreted;
- Recording and maintaining test data accurately;
- Identifying CQA-tested work that should be accepted, rejected, or further evaluated;
- Verifying that corrective measures are implemented;
- Documenting and reporting CQA activities;
- Collecting data needed for record documentation.
- Maintaining open line of communications with other parties involved in the construction.

The CQA Officer is also responsible for approving the work for major construction activities associated with the landfill construction and closure construction.

Approvals shall be issued by a Professional Engineer attesting that construction and all test evaluations are in compliance with South Carolina Rules and Application specifications and bear the seal of the Professional Engineer licensed in the state of South Carolina.

The CQA Officer shall be pre-qualified and approved by the Owner. The CQA Officer shall be a qualified engineering firm with experience in construction quality assurance and quality control, particularly on projects involving similar landfill construction systems. The CQA Officer shall be capable of assigning technically qualified personnel to the project, including an on-site CQA Resident Project Representative (RPR) as needed. The CQA RPR shall possess a thorough knowledge of all aspects of earthwork, low permeability soil liners and geosynthetics construction.

1.5.5.3 Qualifications

The CQA Officer shall be a Professional Engineer licensed by the State of South Carolina. The CQA Officer shall be familiar with lined landfill construction and closure techniques and all applicable regulatory requirements.

1.5.6 Quality Assurance Laboratory

1.5.6.1 Definition

Quality Assurance Laboratory is a firm or firms, independent from the Contractor, Manufacturer, and Installer, responsible for conducting tests on samples of geosynthetics (geomembrane, geocomposites and geotextiles) and soils proposed for use or used in construction at the site.

The Soils CQA Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine soils characteristics as required by the specifications. The Soils CQA Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Soils CQA Laboratory shall also demonstrate to the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports.

The Geosynthetics CQA Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine geosynthetics characteristics as required by these specifications. The Geosynthetics CQA Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Geosynthetics CQA Laboratory shall also demonstrate the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports. The Geosynthetics CQA Laboratory shall hold current accreditation from the Geosynthetic Accreditation Institute (GAI) for all pertinent test methods.

1.5.6.2 Responsibilities

The Quality Assurance Laboratory shall be responsible for conducting the appropriate laboratory tests as directed by the CQA Officer and in accordance with the project plans and specifications.

1.5.6.3 Reporting

The Quality Assurance Laboratory shall be responsible for providing all tests results to the CQA Officer in written form within 24 hours of receipt of test samples results. Written test results shall be in an easily readable format and include references to the standard test methods used.

1.5.7 CONTRACTOR

1.5.7.1 Definition

The Contractor is the party with which the Owner has entered into agreement to construct the project.

1.5.7.2 Responsibility

The Contractor is responsible for meeting the requirements of the contract documents and the successful completion of the landfill construction project. The Contractor is responsible for all items of work on the project including but not limited to earthwork, sedimentation and erosion control, earthwork, soil liners, geosynthetic (HDPE, LLDPE, etc.) liners, geocomposite drainage nets, protective cover and drainage layers, installation of crushed stone roads, and all other associated appurtenances. The Contractor shall be responsible for the quality of the materials and installation of the materials in conformance with the contract documents. The Contractor shall be responsible for the quality of work and materials supplied by all of its subcontractors. Contractor shall be responsible for the quality of work and materials supplied by manufacturers.

It is the Contractor's sole responsibility to provide adequate CQC measures for the work to be performed. The Contractor shall not rely on the Owner's CQA services for determining compliance with the contract specifications. The Contractor's specific responsibilities include but are not limited to: providing qualified personnel to perform quality control, providing the CQC Officer, providing acceptable submittals for the various materials as required by the specifications, scheduling and coordinating the work with suppliers and subcontractors, providing a competent resident construction superintendent and an on-site CQC representative at all times during construction, providing licensed land surveying services well-versed in landfill construction, furnishing progress reports, drawings and record drawings, attending progress meetings, providing monthly updated schedules at minimum, and notifying the Owner of design inconsistencies or contradictions. The surveyor shall be a Registered Land Surveyor, licensed by the State of South Carolina.

1.5.7.3 Qualifications

The Contractor's Project Manager and Superintendent shall have a minimum of 10 years of progressive experience with landfill construction work and specifically with construction of low permeability soil liners and geosynthetic liners.

1.5.8 Quality Control Laboratory

1.5.8.1 Definition

The Quality Control Laboratory is a firm, independent from the Contractor, Manufacturer, and Installer, responsible for conducting tests on samples of geosynthetics (geomembrane, geocomposites and geotextiles) and soils used in the construction of the facility.

The Soils CQC Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine soils characteristics as required by the specifications. The Soils CQC Laboratory shall demonstrate that it follows the standard test methods listed in

the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Soils CQC Laboratory shall also demonstrate to the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports.

The Geosynthetics CQC Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine geosynthetics characteristics as required by the specifications. The Geosynthetics CQC Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Geosynthetics CQC Laboratory shall also demonstrate to the CQA Officer's satisfaction that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports. The CQC Geosynthetics Laboratory shall hold current accreditation from the Geosynthetic Accreditation Institute (GAI) for all pertinent test methods.

1.5.8.2 Responsibilities

The Quality Control Laboratory shall be responsible for conducting the appropriate laboratory tests as directed by the CQC Officer and in accordance with the project plans and specifications.

The Quality Control Laboratory shall be responsible for providing all tests results to the CQC Officer in written form within 24 hours of receipt of test samples results. Written test results shall be in an easily readable format and include references to the standard test methods used.

Note: Qualifications of the CQC firm and Resumes for the CQC Officer and CQC field personnel must be provided to the Owner and CQA Officer for approval. Field personnel shall have a minimum of 4 years of field experience with the material/operation being inspected and/or tested, and specifically with the construction of low permeable soil liners. QC and QC Field personnel shall not be replaced unless approved by the Engineer and CQA Officer.

1.5.9 Manufacturer

1.5.9.1 Definition

The Manufacturer is the firm or corporation responsible for production of material to be used in the project.

1.5.9.2 Responsibilities

The Manufacturer shall produce a consistent product meeting the project specifications and shall provide quality control documentation for its product as specified in the construction specifications.

1.5.9.3 Qualifications

Each geosynthetic Manufacturer shall provide sufficient production capacity and qualified

personnel to meet the demands of the project as identified in the specification. Each Manufacturer shall have an internal quality control program for its product that meets the specified requirements.

Each Manufacturer shall meet the following requirements and submit the following information:

- Corporate background and information
- A list of material properties including certified test results, which are attached to geosynthetic samples, if applicable.
- For liner systems, a list of at least 10 completed landfill or surface impoundment facilities totaling a minimum of 3,000,000 SF for which the Manufacturer has manufactured a geosynthetic product. For each facility, the following information shall be provided: Name and purpose of facility, its location, and date of installation, name of owner, project manager, designer, fabrication (if any), and installer, type of geosynthetic and the surface area of installed geosynthetic, available information of the performance of the lining system and the facility.
- The Manufacturer's Quality Control Manual, including a description of the quality control laboratory facilities and pertinent accreditation.
- The Manufacturer's Field Installation Quality Control Manual. The Manufacturer's and Installer's QC Manual shall comply with the Contract Documents. At a minimum, the manual shall contain procedures and recommendations for the following: Geosynthetics deployment, field panel placement, geosynthetics field seaming, seam testing (destructive, non-destructive for field and laboratory settings), repair of defects
- The origin (supplier's name and production plant, and identification (brand name and number) or resin used to manufacture the product.

Pre-installation: Prior to the installation of any geosynthetic material, each Manufacturer must submit to the Engineer and CQA Officer all quality control documentation required by the appropriate section of the specifications. This documentation shall be reviewed and approved by the Engineer and CQA Officer before installation can begin.

1.5.10 Installer

1.5.10.1 Definition

The Installer is the company responsible for the installation of a particular component of the landfill containment system such as the geosynthetic liner, geosynthetics, leachate collection piping, manholes, pumps and systems. This is not limited to synthetic products. The Installer is a Manufacturer or an approved installer trained and certified to install a Manufacturer's product.

The Installer shall be trained and certified to install the material used, and shall be able to provide qualified personnel to meet the demands of the project.

1.5.10.2 Responsibilities

The Installer shall be responsible for field handling, storing during the installation process, deploying, seaming, curing, temporary restraining, and all other aspects of the product installation. The Installer shall be responsible for submittal of the documentation listed to the Contractor.

Pre-installation: Prior to commencement of the installation, the Installer must submit to the CQA Officer through the CQC Officer and Contractor:

- Resume of the Installation Supervisor to be assigned to this project, including dates and duration of employment, and relevant experience and qualifications.
- A preliminary (panel) layout drawing showing the installation layout identifying field seams (or connections) as well as any variance or additional details, which deviate from the engineering drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
- Deviation from the layout plan must be approved by the CQA Officer prior to installation.
- Installation schedule
- A list of personnel performing field (seaming) operations along with pertinent experience information and certifications
- All required (HDPE, geosynthetic, etc.) quality control certificates
- Certification that HDPE extrudate to be used is comprised of the same resin as the geomembrane to be used for the geosynthetic phase of the project

This CQA Plan shall be reviewed by the Installer before installation during the applicable phase of construction (geosynthetics, piping, etc.) begins.

Installation (geomembrane liner): During the installation, the Installer shall be responsible for the submission of subgrade surface acceptance certificates for each area to be covered by the lining system, signed by the Installation Supervisor.

Completion: Upon completion of the installation, the Installer shall submit:

- The warranty obtained from the Manufacturer.
- The installation warranty
- Record drawings clearly delineating panels, seams, repairs, repair patches, and location of destructive samples
- All QC field reports and documents

The drawings shall be reviewed and certified by the CQC Officer for accuracy. The QC field report documents and drawings shall be submitted to the CQA Officer for review and acceptance.

The Installation Supervisor is the individual provided and assigned by the Installer to be the field representative providing supervision and guidance to the installation crew.

The Installation Supervisor is responsible for coordinating the installation of the material or system (geomembrane liner, geosynthetics, piping, connections, seaming, etc.). The Installation Supervisor is responsible for obtaining samples for field testing and for coordinating testing activities with the Contractor and CQA Officer. The Installation Supervisor is responsible for keeping a daily log of all activities related to geosynthetic products installation and testing and for attending all related project meetings.

1.5.10.3 Qualifications

The Installer shall provide, through the Contractor, the Engineer and CQA Officer with the information demonstrating qualifications as follow:

- Corporate background and information
- Description of installation capabilities:
- Information on equipment (numbers and types), and personnel (number of site managers and number of crews)
- Average daily production anticipated.
- Samples of field geomembrane seams and a list of minimum values for geomembrane seam properties.
- Experience as required by individual Specification Sections. For each installation, the following information shall be provided:
- Name and purpose of facility, its location, and date of installation
- Name of owner, project manager, designer, manufacturer, fabricator (if any), and name of contact at the facility who can discuss the project
- Name and qualifications of the Superintendent(s) of the Installer's crew(s)
- Type of geosynthetic and surface area installed.
- Type of seaming and type of seaming apparatus used
- Duration of installation
- Available information on the performance of the lining system and the facility
- The Installer's quality control manual. Should the manual be in conflict with the specifications or drawings, the specifications and drawings shall control.
- A copy of a letter of recommendation supplied by the geomembrane Manufacturer

The Installation Supervisor must be qualified based on previously demonstrated experience, management ability, and authority. The Geosynthetic Installation Supervisor shall have previously managed the installation of seaming apparatus to be used at the site. The Drainage Net Supervisor must have installed at least one net system. The pipe installer must have completed manufacturers training for fusing pipe.

PART 2: PRODUCTS

Not applicable.

PART 3: EXECUTION

3.1 Communication between Involved Parties

To achieve a high degree of quality during construction and to assure a final product that meets all project requirements, clear, open channels of communication are essential; it is essential that lines of communication are open and active in addition to conducting regular project meetings at the site.

3.1.1Pre-construction Conference

A Pre-construction conference shall be held prior to commencement of the work. At a minimum, the meeting shall include the Owner, Engineer, CQA Officer, Contractor (Project Manager and Superintendent), CQC Officer, and Installers as applicable. The Permitting Agency will be notified of the meeting will attend as deemed appropriate.

The meeting will include, but not be limited to, a review of the project site, project documents, modifications of these documents, the responsibilities and duties of each party, lines of authority and communication, the construction work plan, the proposed schedule and critical path, a discussion of the procedures and schedule for periodic reporting for testing and construction activities, testing protocols, locations of soils, stockpiling, etc.. The Contractor shall present and distribute schedules at the meeting.

3.1.2 Progress Meetings

At minimum, monthly progress meeting shall be held between the Owner, Engineer, CQA Officer, Contractor, CQC Officer, and other involved parties. Weekly or bi-weekly progress meetings will be held as needed. Those attending will discuss current progress, planned activities for the next week, and new business or revisions to the work. The Engineer will log problems, decisions, or questions arising at this meeting. Minutes of these meeting will be submitted by the Engineer to the Owner for approval and distributed to the appropriate parties within 5 workdays from the meeting.

3.1.3Problem or Work Deficiency Meeting

A special meeting shall be held when and if a problem or work deficiency is present or likely to occur. At a minimum, the meeting should be attended by the Owner, Engineer, CQA Officer, Contractor, and the CQC Officer. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency;
- Review alternate solutions; and
- Implement an action plan to resolve the problem or deficiency.

The Engineer shall document the meeting and minutes shall be transmitted to the parties involved.

3.2 Quality Assurance Testing

The Contractor shall be aware (and allow for in his schedule) that the CQA Officer will observe or inspect at their discretion, any or all portion of the work and the Contractor shall afford all necessary assistance to the CQA Officer in carrying out such quality assurance tests and checks. The Contractor shall immediately make any necessary corrections to the work. Such checking by the CQA Officer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work. The Contractor shall factor this quality assurance inspection and testing into his schedule and sequence of operations. Any such quality assurance inspection and/or testing by the CQA Officer will not be grounds for request by Contractor for time extensions or extras. Special elements of the CQA testing will require coordination with respect to scheduling of field personnel. The Contractor shall notify the CQA Officer within 72 hours of that need.

3.3 Deficient/Substandard Work

If the quality control or quality assurance testing shows a pattern or trend of the Contractor's work not meeting the minimum standards established in the Contract Documents, the Contractor shall immediately adjust and/or change his mode of operation, his equipment, his on-site personnel, his construction methods and techniques, his quality control efforts, etc. as necessary (and subject to the approval of the Engineer and CQA Officer) to bring the work into compliance with the minimum quality standards. If the Contractor's work is consistently and/or frequently failing to comply with the minimum quality standards, then the Owner may assess the Contractor the cost for the quality assurance time and expenses and testing associated with (1) retesting where previous tests showed the work not to be in compliance with the minimum standards; and (2) increased quality assurance testing efforts and frequency as deemed necessary by the CQA Officer to confirm that the previously deficient work is being done in accordance with the Contract Documents.

3.4 Anticipated Testing Type and Frequency

The quality control/quality assurance testing anticipated for the work and the type and frequency of such testing is stated in each individual specification section. These testing methods and frequencies are the anticipated level of effort and may be increased or decreased as deemed necessary by the CQA Officer to ascertain the quality of work.

3.5 Documentation

3.5.1 Introduction

The ultimate value of a CQA plan depends to a large extent on recognition of all of the construction activities that should be inspected and the assignment of responsibilities to CQA and CQC inspection personnel for the inspection of each activity. This is most effectively accomplished by documenting CQA activities. The CQA Officer and CQC Officer shall provide the Engineer with signed descriptive remarks, data sheets, and logs to verify that all monitoring activities have been carried out. The CQA Officer and CQC Officer shall also maintain a complete file of design plans, permit specifications, the CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

3.5.2 Daily Record Keeping

Standard daily reporting procedures should include preparation of the following documents:

- Daily Summary Report from the field (CQA and CQC)
- Observation Logs and Test Data Sheets (CQA and CQC)
- Construction Problem and Solution Report (Engineer)
- Photographic Reporting Data Sheets (CQA)

3.5.2.1 Daily Summary Report

Daily summary reports should be prepared daily by the CQA Officer and CQC Officer and/or their designated representative in the field. This daily report provides the chronological framework for identifying and recording all other reports. At a minimum, the summary reports should include the following information:

- An identifying sheet number for cross-referencing and document control;
- Date, project day, project name, location, and other identification;
- Data on weather conditions;
- Reports on any meetings held and their results;
- A reduced-scale site plan showing all proposed work areas and test locations;
- Descriptions and locations of ongoing construction;
- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- Locations where tests and samples were taken or reference to specific observation logs and/or test data sheets where such information can be found;
- A summary of field/laboratory test results or reference to specific observation log and/or test data sheets;
- Calibrations or recalibrations of test equipment and actions taken as a result of recalibration, or reference to specific observation logs and/or test data sheets;
- Off-site materials received, including quality and quantity verification documentation;
- Decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in instances of substandard quality;
- The CQA Officer and his/her on-site representative's and/or the CQC Officer and his/her on-site representative's signature as applicable.

3.5.2.2 Observation Logs and Test Data Sheets

All observations, and field and/or laboratory tests, should be recorded on project-specific logs and data sheets. Recorded observations may take the form of notes, charts, sketches, photographs, or any combination of these. Where possible, a checklist may be useful to ensure that no pertinent factors of a specific observation are overlooked. At a minimum, the logs and data sheets shall include the following information:

- An identifying sheet numbered for cross referencing and document control;
- Date, project name, location, and personnel involved in the inspection activity.
- Description or title of activity monitored;
- Location of inspection activity and locations of samples collected;

- Type of inspection activity; procedure used (reference to standard method when appropriate);
- Results of laboratory tests received;
- Results of monitoring activity in comparison to specifications; and
- The CQA monitor's or CQC Officer's signature as applicable.

3.5.2.3 Problem Identification and Solution Reports

A problem is defined herein as material or workmanship that does not meet the specified design. Problem Identification and Solution Reports should be cross-referenced to specific observation logs (or daily filed reports) and test data sheets (or summary tables). The report shall include the following information:

- An identifying sheet number for cross-referencing and document control;
- A detailed description of the situation or deficiency;
- The location and probable cause of the situation or deficiency;
- How and when the situation or deficiency was found or located; Documentation of the response to the situation or deficiency;
- Final results of any responses;
- Any measures taken to prevent a similar situation from occurring in the future; and
- The signature of the Engineer.

The Owner shall be made aware of any significant recurring nonconformance with the permit specifications. The Engineer shall then determine the cause of the non-conformance and recommend appropriate changes in procedures or specifications. Any changes will be submitted to the Owner for approval. When this type of evaluation is necessary, the results shall be documented and any revision to procedures or permit specifications will be approved by the Owner, Engineer, and, if necessary, the Permitting Agency.

3.5.2.4 Photographic Reporting Data Sheet (CQA)

Photographic reporting data sheets, where used, shall be cross-referenced with observation logs and test data sheets and/or construction problem and solution reports. Photographic reporting data sheets should include the following information:

- A unique identifying number on data sheets and photographs for cross-referencing and document control;
- The size, scale, and orientation of the subject matter photographed; Location and description of the work;
- The purpose of the photograph;
- The name of the photographer and concurrence of the CQA Officer's representative.

These photographs will serve as a photographic record of work progress, issues, and corrective measures. They should be kept in a permanent protective file in the order in which they were taken.

3.6 Final Documentation

At the completion of the work, the CQC Engineer shall submit to the Engineer a signed Final Certification Documentation. At a minimum, the Certification Report shall include:

- Summary reports of all construction activities;
- Observation logs, test data sheets and test results and summary tables including sample location maps and supporting field and laboratory tests results;
- Construction issues and solutions reports;
- Record surveys;
- A summary statement sealed and signed by a Professional Engineer licensed in the State of South Carolina; and
- All approvals or certifications pertinent to the landfill project.

The record plans shall include scale plans depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). Surveying and base maps required for development of the record plans shall be done by a qualified land surveyor licensed in the State of South Carolina.

END OF SECTION

SECTION 01050

FIELD ENGINEERING

PART 1: GENERAL

1.01 SCOPE OF WORK

A The CONTRACTOR shall retain the services of a registered land surveyor licensed in the State of South Carolina.

1. Identify existing control points and property line corner stakes indicated on the Drawings, as required.

2. Verify all existing structure locations and all proposed equipment locations.

3. Maintain an accurate location of all buried piping.

1.02 RELATED WORK

A Section 01025: Measurement and Payment

B Section 01040: CQA Plan

1.03 SUBMITTALS

A Submit name, address and copy of licensure of the registered land surveyor proposed to be used on this PROJECT to the ENGINEER within 15 days of the Notice to Proceed.

B On request of the ENGINEER, submit documentation to verify accuracy of field engineering work.

C The CONTRACTOR is required to perform surveys signed and sealed by the registered land surveyor. All surveys shall be tied to the existing permanent survey monuments at the site, as identified on the drawings. These drawings shall be included with, and made a part of, the PROJECT record documents. The CONTRACTOR shall also submit each survey on CD-ROM in AutoCAD Release 2000 or newer and/or Terramodel software format. All elevation information in the file must be at appropriate 3-D elevation. All entities shall be placed on layer names which adequately describe the entity being mapped.

D The CONTRACTOR is required to perform the following surveys and submit to the ENGINEER.

1. The CONTRACTOR shall provide certified topographic map surveys and Digital Terrain Models (DTM) of the following:

a. Pre-work Survey: Immediately following clearing and grubbing and stripping and prior to starting excavation and/or backfill. Pre-Work Survey shall include surveys of existing surface utilities.

b. Subgrade Plan Survey: Immediately following completion of excavation and backfill per the Subgrade Plan and prior to starting placement of the subsequent layer (compacted soil liner, protective cover layer, drainage layer, stone road paving).

c. Post-work Survey: Following completion of placement of landfill compacted soil liner and protective cover layer; to include landfill operational berms, diversion berms, ditches, and roads where applicable.

The surveys shall meet the following criteria: 1" = 100' scale reproducible plot produced at national map accuracy standards for 1" = 100' scale maps with 2' contour interval.

The DTM must contain adequate 3-D points and 3-D break lines required to accurately model the photographed surface to within above stated accuracy. The DTM must also provide a 2-D polyline defining the limits of the area surveyed. The points, break lines, and survey limits line shall be on separate layers. AutoCAD files of the DTM model must be compatible for use with Terramodel software.

2. Compacted Soil Liner and Protective Cover Surveys

The CONTRACTOR shall provide Surveys that show the constructed horizontal limits of Compacted Soil Liner (and geomembranes as applicable), and Protective Cover layers, respectively.

The Compacted Soil Liner and Protective Cover Surveys shall also include a grid survey that shows the elevations of each of the following components of the liner system: 1) elevations of the Compacted Soil Liner subgrade, 2) elevations of the finish grade of the Compacted Soil Liner, and 3) elevations of the finish grade of the Protective Cover taken on a grid pattern of 50-foot centers, and at all breaks in grade. Identical horizontal points for all three grades shall be required.

CONTRACTOR shall submit *proposed* grid survey points for approval by ENGINEER prior to placement of compacted soil liner. No Compacted Soil Liner shall be placed without a certified survey stating that the subgrade elevations conform to the grades shown on the Subgrade Plan is submitted to and approved by the ENGINEER. No geomembrane or overlaying layer shall be placed until a certified survey is submitted and approved by the Engineer demonstrating that the surface of the Compacted Soil Liner conforms to the Project Drawings and that the thickness of the

Compacted Soil Liner is a minimum of 24-inches at all grid points within the landfill or as specified in the Contract Documents, i.e. an alternate liner system.

All grid points shall be accompanied by a spreadsheet (survey grid table), certified by the Surveyor, indicating point number, subgrade elevation, top of clay elevation, clay thickness, top of protective cover, and protective cover thickness.

3. Certified survey of the limits of work, and surface and subsurface structures installed by CONTRACTOR shall be provided after completion of the PROJECT and shall include the following:

   a. Limits of Work – Including, but not limited to:
      i. limits of cleared and grubbed
      ii. limits of stone road paving
      iii. limits of seeded and mulched

   b. Surface Facilities – Including, but not limited to:
      i. Rip-rap aprons, ditches and outlet energy dissipaters
      ii. Stormwater management structures (ditches, berms)
      iii. Collection pipes, header pipes and clean-outs
      iv. Manholes and pumping systems
      v. Any other surface facilities installed by the Contractor.

   c. Subsurface Facilities – Including, but not limited to:
      i. Pipe (indicating alignment and invert elevations, elbows, valves, etc.)
      ii. Pipe drop inlets (including grate elevations and pipe inverts)
      iii. Pump station pipe invert elevations
      iv. Force main pipe alignment
      v. Buried electrical conduit
      vi. Any other subsurface facilities installed by the Contractor.

1.04 QUALIFICATIONS OF SURVEYOR and EQUIPMENT

A Registered land surveyor of the discipline required for the specific service on the PROJECT, currently licensed in the State of the South Carolina.

B All survey instruments should be capable of reading to a precision of 0.01 ft and with a setting accuracy of 20 sec. (5.6×10^{-3} degrees).

1.05 SURVEY REFERENCE POINTS

A Existing basic horizontal and vertical control points for the PROJECT are those designated on Drawings.

B Locate and protect control points prior to starting site work and preserve all permanent reference points during construction.

1. Make no changes or relocations without prior written notice to the ENGINEER.

2. Report to the ENGINEER when any reference point is lost or destroyed, or requires relocation because of necessary changes in grades or locations.

3. Require surveyor to correctly replace PROJECT control points which may be lost or destroyed.

a. Establish replacements based on original horizontal and vertical survey control.

1.06 PROJECT SURVEY REQUIREMENTS

A Establish a minimum of two permanent benchmarks on site, referenced to data established by survey control points.

1. Record locations, with horizontal and vertical data, on PROJECT Record Documents.

B Establish lines and levels, locate and lay out, by instrumentation and similar appropriate means:

1. Site improvements

a. Stakes for grading, fill and topsoil placement.

b. Utility slopes and invert elevations.

C From time to time, verify layouts by same methods.

D Establish all lines and grades prior to construction of line work for all pipelines at 100-ft increments and at defined breaks in grade.

1.07 RECORDS

A Maintain a complete, accurate log of all control and survey work as it progresses.

B Update the PROJECT Record Drawings on a monthly basis based on the work performed during the month ending at the pay request as a condition for approval of monthly progress payment requests.

C Maintain an accurate record of piping changes, revisions, and modifications.

D All field survey notes will be retained by the Surveyor. The results from the field surveys will be documented on a set of Survey Record Drawings signed and sealed by a registered Professional Engineer or Professional Land Surveyor licensed in the State of South Carolina for submittal to the ENGINEER. The CONTRACTOR shall certify to the ENGINEER that the results of the survey demonstrate compliance with the Contract Documents. These drawings shall, at a minimum, show the final elevations and locations of all surfaces and appurtenances surveyed.

PART 2: PRODUCTS (NOT USED)

PART 3: EXECUTION (NOT USED)

END OF SECTION

SECTION 02100

SITE PREPARATION

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, and equipment required and perform all clearing and grubbing, including stripping of topsoils complete as shown on the Drawings and as specified herein.

B Obtain all permits required for site preparation work prior to proceeding with the work, including clearing and grubbing.

1.02 RELATED WORK

A Section 02200: Excavation Backfill, and Compaction

B Section 02276: Erosion and Sedimentation Control

C Section 02985: Stabilization

1.03 SUBMITTALS

A Submit in accordance with Section 01030 copies of all permits required prior to clearing and grubbing work.

PART 2: PRODUCTS - Not Used

PART 3: EXECUTION

3.01 SURVEY

A The CONTRACTOR shall locate and stake out the limits of clearing and grubbing.

3.02 CLEARING

A Clear only those areas required to install the erosion control measures as shown on the plans prior to starting overall clearing operations.

B Cut and remove timber, trees, stumps, brush, shrubs, roots, grass, weeds, rubbish, and any other objectionable material resting on or protruding through the surface of the ground.

C Trees and other vegetation designated on the Drawings or directed by the ENGINEER to remain shall be preserved and protected as specified.

3.03 GRUBBING

A Grub and remove all stumps, roots in excess of 1-1/2 inches in diameter, matted roots, brush, timber, logs, concrete rubble, and all other debris encountered in the designated clearing limits.

B All grubbing holes and depressions excavated below the original ground surface shall be filled with suitable common fill and compacted to the specified density and conforming to the surrounding ground surface unless otherwise indicated.

3.04 DISPOSAL

A All vegetation and debris within the areas to be cleared shall become property of the CONTRACTOR upon the start of work

B The CONTRACTOR shall dispose of all material and debris from the clearing and grubbing operation at an approved location or as otherwise approved by the OWNER.

C Burning of combustible materials removed by clearing and grubbing may be allowed if approved by the OWNER and provided the CONTRACTOR obtains all required permits and operates in compliance with all pertinent federal, state, and local agencies.

3.05 PROTECTION

A Trees and other vegetation designated on the Drawings or directed by the ENGINEER to remain shall be protected from damage by all construction operations by erecting suitable barriers, guards, and enclosures, or by other approved means. Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees and vegetation designated to remain and to the work being constructed and so as to provide for the safety of employees and others.

B Protection shall be maintained until all work in the vicinity of the work being protected has been completed.

C Heavy equipment operation or stockpiling of materials shall not be permitted within the branch spread of existing trees.

D Any damage to existing tree crowns, trunks, or root systems shall be repaired immediately. Roots exposed and/or damaged during the work shall immediately be cut off cleanly inside the exposed or damaged area. Cut

surfaces shall be treated with acceptable tree wound paint, and topsoil spread over the exposed root area.

E When work is completed, all dead and downed trees shall be removed. Live trees shall be trimmed of all dead and diseased limbs and branches. All cuts shall be cleanly made at their juncture with the trunk or preceding branch without injury to the trunk or remaining branches. Cuts over 1-in in diameter shall be treated with acceptable tree wound paint.

F Construction activities shall be restricted to those areas within the limits of construction designated on the Drawings, within public rights-of-way, and within easements provided by the OWNER. Adjacent properties and improvements thereon, public or private, which become damaged by construction operations, shall be promptly restored to their original condition, to the full satisfaction of the property owner.

3.06 EXISTING INTERMEDIATE COVER PREPARATIONS (FOR CLOSURE ONLY)

A Proof-roll exposed intermediate cover (subgrade) after stripping organics, prior to placement of Infiltration Layer material and/or geomembrane liner, with a minimum of two complete passes of a rubber tired vehicle as approved by the Engineer. All proof-rolling shall be conducted in the presence of the Engineer or the RPR. The Engineer may require excavation and grading of existing intermediate cover and waste mass and replacement with Backfill and/or installation of geogrid fabric, or other remediation as necessary to provide a firm, dry, stable subgrade in areas that appear to be rutting, pumping, leaching, or otherwise appear unstable while proof-rolling. Geogrid shall consist of BX-1100 geogrid, or equivalent, as approved by the Engineer.

B The Engineer and/or RPR shall be notified if unpredicted subsurface conditions are encountered during excavation, grading, fill placement or flexible membrane liner placement. Areas that indicate excessive rutting, pumping, shoving, or movement during proof-rolling may require repair. Any and all repairs shall be performed as approved by the Engineer. All Backfilling shall be performed as approved by the Engineer and according the Section 02200, Excavation, Backfill, and Compaction.

END OF SECTION

SECTION 02200

EXCAVATION, BACKFILL, AND COMPACTION

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary to perform all excavation, backfill, compaction and grading required to complete the work shown on the Drawings and specified herein. The work shall include, but not necessarily be limited to excavation, backfilling, grading, compaction, disposal of waste and surplus materials, placing crushed stone, construction of berms, and all related work such as sheeting, bracing and de-watering.

B. All excavation, trenching, and related sheeting, bracing, etc. shall comply with the requirements of OSHA excavation safety standards 29 CFR Part 1926.650 Subpart P and State requirements. Where conflict between OSHA and State regulations exists, the more stringent requirements shall apply.

C. Excavated topsoil and excess cut material will be stockpiled in locations approved by the OWNER.

1.02 RELATED WORK

A. Section 01050: Field Engineering

B. Section 01410: Construction Quality Assurance / Quality Control Plan

C. Section 02100: Site Preparation

D. Section 02276: Erosion and Sedimentation Control

E. Section 02985: Stabilization

1.03 SUBMITTALS

A. A signed certification letter, with all necessary permits, that the source is in full compliance with State, County and local laws and regulations for each source.

B The CONTRACTOR shall furnish a representative sample weighing approximately 75 pounds of each fill material, stone and crushed stone to the CQA Officer for approval, at least 15 calendar days prior to the date of anticipated use of such material.

C. Excavation support designs shall be prepared by a licensed professional engineer, registered in the State of South Carolina, having a minimum of five

years of professional experience in the design and construction of excavation support systems.

D. De-watering and drainage system designs shall be prepared by a licensed professional engineer, registered in the State of South Carolina, having a minimum of five years of professional experience in the design and construction of dewatering and drainage systems.

1.04 QUALITY ASSURANCE / QUALITY CONTROL

A. Owner shall employ a CQA Officer and Quality Assurance Laboratory to perform soils observation and testing services for quality assurance of the fill material. Contractor shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of fill material.

1.05 PROTECTION

A. Sheeting and Bracing (if required)

1. Furnish, put in place and maintain such sheeting and bracing as may be required by Federal, State and local safety requirements to support the sides of excavations; to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction; and to protect adjacent structures from undermining or other damage. If the Engineer is of the opinion that at any location sufficient or proper supports have not been provided, he/she may order additional supports put in, and compliance with such order shall not relieve or release the Contractor from his/her responsibility for the sufficiency of such supports. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled and rammed. Where soil cannot be properly compacted to fill a void, lean concrete shall be used as backfill. All voids shall be filled to the satisfaction of the CQA Officer.

2. Construct the sheeting outside the neat lines of the foundation, unless indicated otherwise, to the extent deemed desirable for the method of operation. Sheeting shall be plumb and securely braced and tied in position. Sheeting and bracing shall be adequate to withstand all pressures to which the structure or trench will be subjected. Any movement or bulging which may occur shall be corrected to provide the necessary clearances and dimensions.

3. All sheeting and bracing shall be carefully removed in such manner as not to endanger the construction or other structures, utilities, or property. All voids left or caused by withdrawal of sheeting shall be immediately re-filled with sand, which must be approved by the CQA Officer, by ramming

with tools especially adapted to that purpose, or otherwise as may be directed.

4. The right of the CQA Officer to order sheeting and bracing left in place shall not be construed as creating any obligation on his/her part to issue such orders and his/her failure to exercise his/her right to do so shall not relieve the Contractor from liability for damages to persons or property occurring from or upon the work occasioned by negligence or otherwise, growing out of a failure on the part of the Contractor to leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

5. No sheeting is to be withdrawn if driven below mid-diameter of any pipe and under no circumstances shall any sheeting be cut off at a level lower than 1-ft above the top of any pipe.

B Drainage and De-watering

1. Dewatering shall be performed as specified during the excavation of organics and unstable soils from the site. Limited dewatering may be required during the excavation and filling of ponds, ditches and where the topsoil layer extends below the water table.

2. At all times during construction provide and maintain proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory undisturbed subgrade condition until the fills, structures or pipes to be built thereon have been completed to such extent that they will not be floated or otherwise damaged by allowing water into the excavated areas. Groundwater shall be lowered to at least 1 foot below the bottom of excavations.

3. De-watering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation. Well or sump installations shall be constructed with proper sand filters to prevent drawing of finer grained soil from the surrounding ground.

4. Surface runoff shall be collected, drained to sumps and pumped from the disposal unit to maintain a excavation bottom free from standing water.

5. De-watering of ponds or ditches filled with water shall be performed in such a manner as to control discharge water by use of sediment basins and/or check dams or other erosion control structures approved by SCDHEC.

6. Take all additional precautions to prevent uplift of any structure during construction.

7. Drainage shall be disposed of so that flow or seepage back into the excavated area will be prevented.

8. Flotation shall be prevented by maintaining a positive and continuous operation of the dewatering system. The Contractor shall be fully responsible and liable for all damages which may result from failure of this system.

9. Remove the dewatering equipment after the system is no longer required.

10. Take all necessary precautions to preclude the accidental discharge of fuel, oil, etc in order to prevent adverse effects on groundwater or surface water quality.

C. SLOPE STABILITY

1. The Contractor shall be solely responsible for the stability of roadway embankments, unbalanced fills, stockpiles, and all other construction operations.

1.06 SOIL TESTING

A. Previous to the placement of the fill and during such placement, the CQA Officer may select areas within the limits of the fill for testing. The Contractor shall cooperate fully in obtaining the information desired.

PART 2: PRODUCTS

2.01 MATERIALS

A. Materials for use as fill shall be as described below. The Contractor shall notify the CQA Officer of the source of each material. On-site borrow areas may be utilized with prior approval from the Owner. Off-site materials shall be furnished as required from approved off-site sources (see 1.03.A) and hauled to the site. All local, state and federal regulations shall apply. The Contractor shall submit copies of all applicable permits and approval to the Owner prior to commencement of the work.

B. Backfill shall consist of mineral soil free from organic materials, loam, wood, trash and other objectionable materials which may be compressible or which cannot be properly compacted. Common fill shall not contain stones larger than 4 inches in largest diameter and shall have at least 60 percent passing the No. 4 sieve, a maximum of 60 percent passing No. 200 Sieve, a maximum liquid limit of 60, and a maximum plasticity index of 25. Common Fill shall not contain granite blocks, broken concrete, masonry rubble or other similar materials. It shall have physical properties such that it can be readily spread and compacted

during filling. Snow, ice and frozen soil will not be permitted. Common Fill shall be compacted to at least 95% of the standard Proctor (ASTM D698) maximum dry density or as otherwise shown on the drawings.

C. Select Fill shall be as specified above for Backfill except that the material shall contain no stones larger than two inches in largest dimension, a maximum of 50 percent passing the No. 200 Sieve, a maximum liquid limit of 50 and a maximum plasticity index of 15. Select Fill shall be compacted to 98% of the standard Proctor (ASTM D698) maximum dry density.

D. The soils shall be wetted or dried as necessary so that the moisture content during compaction is within 3%of the optimum moisture content as determined by ASTM D698.

E. Highly micaceous and elastic silts shall not be used for Common, Select Fill or Structural Fill.

F. Crushed Stone

1. All crushed stone shall be silica material that is sound, hard, durable, resistant to weathering, as defined by ASTM D2488 and shall be free of overburden, spoil, shale, limestone and organic material. The stone shall be free of deleterious materials such as flat, elongated, friable, decomposed, or micaceous pieces. Broken pieces of concrete, asphalt, or brick are not acceptable. Crushed stone shall be of the size and type shown on the drawings.

G. Not used.

H. Not used.

2.02 CONFORMANCE TESTING

Conformance testing shall be performed by the Contractor's QC Laboratory on samples from each source of backfill material. Material identified for use as backfill shall be tested at the frequency specified in Table 1 and at every change in the material, identified by the CQC Officer of CQA Officer:

TABLE 1

Test	Method	Frequency
Grain Size	ASTM D422	Every 10,000 cy
Atterberg Limits	ASTM D4318	Every 10,000 cy
Moisture/Density	ASTM D698	Every 20,000 cy
Natural Moisture	ASTM D2216	Every 10,000 cy

Results of the tests will be submitted to the Owner's CQA Officer within 24 hours of test completion. The CQA Officer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 GENERAL EXCAVATION

A. General Excavation is expected to consist of removing unsuitable soils identified during proofrolling (Section 3.01.E) and as required as part of the work represented on the Drawings (Grading Plan). The bottom of the excavations shall be rendered firm and dry and in all respects acceptable to the CQA Officer.

B. Excavation and de-watering shall be accomplished by methods that preserve the undisturbed state of subgrade soils. Soils which become soft, loose, "quick", or otherwise unsatisfactory for support of structures, earthen or man-made, as a result of inadequate excavation, de-watering, proofrolling, or other construction methods shall be removed and replaced as required by the CQA Officer at the Contractor's expense.

C. De-watering shall lower the groundwater to at least 1-foot below excavation subgrade and prevent "boiling" condition or detrimental underseepage at the base of the excavation as specified herein.

D. Excavation equipment shall be satisfactory for carrying out the work in accordance with the Specifications.

E. Proofroll exposed subgrades after stripping topsoil and organics with a minimum of two complete passes of a rubber tired heavy vehicle as approved by the CQA Officer. All proofrolling shall be conducted in the presence of the CQA Officer or designated representative. The CQA Officer may require excavation and replacement or other remediation as necessary to provide a firm, stable subgrade in areas that appear to be rutting, pumping, or otherwise appear unstable while proofrolling. The repair procedure shall be determined by the CQA Officer.

3.02 TRENCH EXCAVATION

A. Excavation for all trenches required for the installation of pipes shall be made to the depths indicated on the Drawings and in such a manner and to such widths as will give suitable room for laying the pipe within the trenches, for bracing and supporting the trench sides and for pumping and drainage facilities. Contractor shall render the bottom of the excavations firm and stable and in all respects acceptable to the CQA Officer.

B. The trench may be excavated by machinery to, or just below the designated subgrade provided that the material remaining in the bottom of the trench is not disturbed.

C. Where pipe is to be installed in fill, fill shall be placed and compacted to at least 2 ft. above the top of the pipe (rough grade elevation) and then trenches re-excavated for pipe installation.

3.03 MISCELLANEOUS EXCAVATION

A. The Contractor shall perform all excavations necessary for the placing of seeding and plants, for constructing roadways, and any other miscellaneous earth excavation required under this Contract.

3.04 GENERAL BACKFILL

A. Materials placed in fill areas shall be placed to the lines and grades shown on the Drawings. Unless otherwise specified, Common Fill shall be used for backfill.

B. Fill shall be placed in accordance with the Contract Document.

C. Material conforming to the requirements of Backfill shall be placed in layers having a maximum compacted thickness of 8-inches measured before compaction and shall be compacted to at least 95 percent of its maximum density as determined by ASTM D698. The minimum frequency of testing shall be 1 test per lift per 10,000 square feet or as directed by the CQA Officer in irregular-shaped fill areas. CQC personnel shall perform testing of Backfill.

D. The surfaces of filled areas shall be graded to smooth true lines, conforming to grades indicated on the grading plan and no soft spots or un-compacted areas will be allowed in the work.

E. No compacting shall be done when the material is covered with frost or is frozen or is too wet either from rain or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have thawed and/or dried sufficiently to permit proper compaction.

F. All backfill shall be placed at a moisture content within 3% of Standard Proctor (ASTM D698) optimum moisture content.

3.05 TRENCH BACKFILL

A. Backfilling over pipes shall begin as soon as practicable after the pipe has been laid, jointed, and inspected. All backfilling shall be performed expeditiously.

1. Backfill shall be placed around the lower half of the pipe and thoroughly rodded and tamped to fill all voids and provide uniform support of the pipe in the bedding zone. Backfill shall be thoroughly compacted by machine tamping in 6-inch layers as required to provide 98% of the Standard Proctor maximum dry density per ASTM D-698.

2. Backfill shall be placed around the upper half of the pipe and to a minimum depth of 12-inches over the top of the pipe. Backfill shall be thoroughly compacted by machine tamping in 6-inch layers as required to provide 98% of the Standard Proctor maximum dry density per ASTM D-698.

3. The remainder of the trench shall be backfilled with Backfill in loose layers not to exceed 8-inches and thoroughly compacted with mechanical tampers as required to obtain the specified 95% compaction.

4. Backfilling under haunches shall be performed manually by tamping rods or similar hand equipment to eliminate voids underneath sides of the pipe or haunch.

5. The minimum frequency for density tests shall be 1 test per lift per 50 feet of trench for all material types or as specified by the CQA Officer. CQC Laboratory personnel shall perform testing of Trench Backfill

3.06 ROAD SUBGRADE

A. The road subgrade for bituminous, concrete, and crushed stone pavement areas in fill sections shall consist of a two-foot thick layer of Backfill compacted to a minimum 98% of the Standard Proctor maximum dry density per ASTM D-698. CQC personnel shall perform testing of Road Subgrade Backfill.

B. The road subgrade for bituminous, concrete, and crushed stone pavement areas in cut sections shall consist of firm natural soils as approved by the CQA Officer.

C. Road subgrades shall be proofrolled as described in Section 02200, 3.01 E.

3.07 HANDLING OF SURPLUS MATERIAL

A. Excavated materials shall not be removed from the site except as specified by the Owner. Materials shall be neatly stockpiled on-site at locations directed by the Owner. Excess materials shall be compacted and stockpiled in accordance with the contractor's fill placement plan. Contractor shall provide erosion and sedimentation control measures as shown on the drawings and specified in the Contract Documents.

3.08 GRADING

A. Grading in preparation for placing soil liner material shall be performed to the elevations shown and otherwise as directed by the Engineer. During the process of grading, the subgrade shall be maintained in such condition that it will be well drained at all times. When required, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the performance or condition of the work.

B. If at the time of grading it is not possible to place material in its final location, it shall be stockpiled in approved areas. Stockpiled material shall be placed, compacted and smooth-rolled at the end of each day to deter water infiltration. No extra payment will be made for the stockpiling or double handling of excavated material.

C. Engineer reserves the right to make minor adjustments in lines or grades if deemed necessary as the work progresses, in order to obtain satisfactory construction.

D. Stones or rock fragments larger than 3-inches in their greatest dimensions will not be permitted in the top 6-inches of the finished subgrade of all fills or embankments.

3.09 INSPECTION/TESTING

A. The CQA Plan – Inspection and testing will be a joint effort between the Contractor and the Owner.

B. Construction QA/CQC observation, inspection and testing – Owner shall employ a CQA Officer and Quality Assurance Laboratory to perform soils observation and confirmation testing services for quality assurance of the fill material. Contractor shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of fill material. Contractor shall factor the Quality Assurance observations and confirmation testing and Quality Control testing into its schedule and sequence of operations.

C. Coordination – Contractor shall be responsible for coordination of field services with the Contractor's CQC Officer, Quality Control Laboratory, and with the Owner's CQA Officer.

D. Initial Observation – Compacted fill and backfill operations shall be performed after the surface has been properly prepared and has been observed and approved by CQA Officer. No Compacted fill shall be placed unless the CQA Officer approves the operation. Any fills placed without CQA Officer's observation and prior approval shall be removed in a manner to avoid damage or disturbance to the existing approved work, and the excavation shall be filled as specified herein, at no additional cost to Owner.

E. Field Control – The minimum testing frequencies for field tests to be performed by the Contractor's Quality Control personnel are identified in Sections 3.04, 3.05, and 3.06. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests or per change in material. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

F. The Contractor's CQC Firm shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the work associated with Excavation, Backfill and Compaction was performed in accordance with the Contract Documents and be prepared and sealed by a Professional Engineer registered in the State of South Carolina. The report shall include a narrative of construction methods and QC procedures employed, summary tables of all field test results, including locations and notations regarding any re-work performed, identification of failed tests, and documentation of re-worked areas with passing tests, as appropriate.

G. Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02271

FABRIC CUSHION

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install fabric cushion complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02700: Protective Cover Layer

B Section 02701: Drainage and Erosion Layer

C Section 02776: Textured High Density Polyethylene (HDPE) Liner

D Section 02777: Textured Linear Low Density Polyethylene (LLDPE) Liner

1.03 SUBMITTALS

A 45 days prior to the materials scheduled installation, submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. Information on factory size, equipment, personnel, number of shifts per day and production capacity per shift.

3. List of typical material property values corresponding to the requirements of the specification and samples of the fabric cushion.

4. Manufacturer's quality control program and manual including description of laboratory facilities.

5. A list of three projects where heavy weight geotextile fabric cushion was used, including:

   a. Name and purpose of project, location, and date of installation.

   b. Name of Owner, design engineer and installer.

   c. Fabric mass per unit area and surface area.

d. Information on performance of the fabric cushion.

6. Shop Drawing, including:

a. Details of overlap, seaming, anchoring, connections and other construction details as well as any variance or additional details which deviate from the Drawings.

7. Installer qualifications and installation schedule

8. A manual that specifically defines the quality control and quality assurance program during installation.

9. Copy of quality control certificates in conformance with Paragraph 2.02. Upon request the Contractor shall supply documentation which will include supporting test data and EPA 9090 test data to assist the Engineer in determining the suitability of the fabric cushion for the intended application.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D 5199-91 - Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

2. ASTM D 5261-92 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.

3. ASTM D 3786 - Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.

4. ASTM D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

5. ASTM D 4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).

6. ASTM D 4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 FABRIC APPLICATIONS

The fabric cushion is to be used for protection of the geomembrane liner. By placement of the fabric cushion directly on the geocomposite and/or HDPE liner, the fabric cushion is to prevent damage from the overlying layer.

1.06 DELIVERY, STORAGE, AND HANDLING

A The fabric cushion shall be shipped, stored, and handled in accordance with ASTM D 4873 and the manufacturer's recommendations with a minimum being as specified herein.

B Each roll will be labeled either by printing directly on the fabric or tagged with a roll identification number, product identification number, manufacturer, product grade, and physical dimensions, thickness and manufacturer's lot number.

C The fabric cushion shall be shipped and stored in opaque protective covering. Upon delivery, the fabric cushion shall be inspected for damage, unloaded and stored with minimal handling. The Contractor will assist the Engineer in conducting inventory, handling and sampling of the fabric cushion at no additional charge.

D No hooks, tongs or other sharp tools or instruments shall be used for handling the fabric rolls. Acceptable methods of transport include the use of slings or a pole that extends a minimum of 1 ft beyond each end to unload or handle individual rolls. The fabric cushion shall not be dragged along the ground.

E The fabric cushion shall be stored with a cover so that it is protected from exposure to sunlight, soil, puncture, and cutting. The rolls shall be elevated from the ground a minimum of 3 inches.

1.07 MATERIAL WARRANTY

A The manufacturer shall warrant the material against manufacturing defects and material degradation for a period of five years from the date of installation. The manufacturer shall replace any material which fails within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.08 GUARANTEE

A The Contractor shall guarantee the fabric cushion against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A Nonwoven Fabric

1. The fabric cushion shall be a nonwoven, needle punched fabric consisting of polypropylene or polyester fibers or filament formed into a stable network, such as SKAPS GE-280, Nicolon Mirafi, or equal. The fabric cushion shall not be heat bonded.

2. The fabric cushion shall be inspected by the manufacturer for broken needles by permanently installed on-line metal detectors at the production facility.

3. The fabric cushion shall be non-biodegradable, nonreactive within a Ph range of three to eleven, resistant to ultraviolet light exposure, and resistant to insects and rodents. The fabric cushion shall have achieved a minimum value of 97 percent for the EPA 9090 chemical resistance test. Test results from any sampled roll in the lot, when tested in accordance with ASTM D4759, shall meet or exceed the values listed in Table 1. All strength values are for the weaker principal direction.

TABLE 1

MINIMUM AVERAGE ROLL VALUES (MARV)
FOR
FABRIC CUSHIONS

PROPERTIES	TEST METHOD	UNIT	MARV
Mass per Unit Area	ASTM D5261	$oz./yd^2$	28
Thickness	ASTM D5199	mils	265±10%
Grab Tensile Strength (MD/CMD)	ASTM D4632	lbs	500/400
Grab Elongation	ASTM D4632	%	50
Mullen Burst Strength	ASTM D3786	psi	650
Trapezoidal Tear	ASTM D4533	lbs	120

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered fabric.

1. Each roll delivered to the Project site shall have the following identification information:

   # Manufacturer's name
   # Product identification
   # Gross roll weight
   # Roll number
   # Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have a roll identification number, testing procedures, frequency and test results. The following test results shall be provided in accordance with ASTM D4354 Table 1 and the test requirements specified in Paragraph 2.02.

   # Thickness
   # Mass per Unit Area
   # Mullen Burst Strength
   # Grab Tensile Strength
   # Trapezoid Tear

2.04 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) approved by the Owner. Engineer shall obtain samples from the material proposed for the project, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Contractor shall pay for the initial test for every change in Lot number. The samples shall be taken across the entire roll width and shall not include the first three feet of material on the roll. The following conformance tests shall be conducted at the QAL:

1. Mass per unit area (ASTM D5261)
2. Mullen burst strength (ASTM D3786)
3. Grab tensile (ASTM D4632)
4. Thickness (ASTM D5199)
5. Trapezoidal Tear (ASTM D4533)

B All conformance test results shall be reviewed by the Engineer and accepted, prior to the deployment of the fabric. All test results shall meet, or exceed, the property values listed in Paragraph 2.02.

C Test specimens shall be obtained from each conformance sample in accordance with the respective ASTM standard. Average values shall be calculated from the test specimen results and compared to the minimum average roll values listed in Table 1. If any average value of a conformance sample is less than the minimum average value specified in Table 1, the sample shall be determined to be a failing sample. If a conformance sample fails, all rolls within the sampled 100,000 sf or lot will be rejected for use on the project unless the Engineer approves additional testing.

D If the Engineer approves additional testing, the Contractor may obtain two additional samples from the failing roll and one sample each from the rolls manufactured immediately before and after a failing roll and have them tested by the QAL at the Contractor's expense. If all four samples pass, then all rolls will be accepted. If either of the samples from the failing roll fails, then that roll will be rejected. If either of the samples from the other rolls fails, then all the rolls within the same 100,000 square feet or lot will be rejected.

E The cost of initial material conformance testing shall be borne by the Owner and shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) selected by the Owner. If the fabric fails the initial material conformance tests, the contractor shall pay for the cost of subsequent conformance testing until all conformance tests are passed and the fabric is accepted by the Engineer.

PART 3: EXECUTION

3.01 REQUIREMENTS PRIOR TO INSTALLATION

A Preparation of the subgrade shall be in accordance with Section 02200, Section 02275, and Section 02776.

B The geomembrane and geocomposite shall be cleaned of stones, liner scrap, and all other materials, and a final inspection of the liner shall be performed by the Engineer or designated CQA representative.

C The fabric cushion shall be inspected by the Engineer for imperfections and damage. All defective rolls shall be removed from the site at the expense of the contractor.

3.02 INSTALLATION

A Fabric Cushion Placement

1. The fabric cushion shall be installed as shown on the Drawings and as specified herein.

2. The fabric cushion shall only be cut using a hook blade knife, scissors with rounded tips or as otherwise approved by the Engineer.

3. The Contractor shall exercise extreme care during installation to prevent damage to the HDPE liner. The Contractor shall prevent rocks, soil, waste materials and other debris from being entrapped between the HDPE liner and the fabric cushion. Only smooth soled shoes approved by the Engineer shall be worn by the installers. The Contractor shall not use the installed fabric cushion as a storage area for tools and supplies.

4. The Engineer shall have the authority to order the immediate stoppage of work as a result of improper installation procedures or any reason that may cause defective installation.

B Seaming Method

1. Adjoining fabric cushion panels shall be overlapped a minimum of 4 inches and heat seamed using a hot-wedge welder. The heat seam shall be continuous along the length of the overlap. The area to be welded shall be clean and dry. The hot-wedge welding equipment shall be capable of continuously controlling and monitoring the temperature of the hot wedge platen.

2. All seams constructed on sloped surfaces that are 4 to 1 or greater shall be vertical seams. All vertical panels placed on 4 to 1 slopes or greater shall extend 5 feet beyond the toe of slope.

C Cover

1. All fabric cushion shall be covered in accordance within the manufactures recommended exposure period, but shall not exceed 45 days. If delay of rock layer installation exceeds 45 days, a protective cover such as a woven geotextile with high UV resistance shall be temporarily placed over the fabric cushion until rock placement occurs.

D Repairs

1. Fabric repairs shall be made with patches of the same material, using an approved seaming system. The patch size shall be twenty-four inches larger in all directions than the area to be repaired. The corners of the patch shall be rounded.

3.03 FIELD QUALITY CONTROL

A Prior to placement of the stone drainage layer, the fabric cushion installation and related work shall be inspected by the CQA Officer and/or the RPR. All work in the system therein being inspected shall be complete, clean and prepared for use. All work shall meet the requirements of cleanliness and workmanship, as determined by the CQA Officer and/or the RPR.

B Probe testing may be conducted on all seams by the CQA Officer (RPR). A dull pointed probe is run along the edge of a seam to detect defects. All defects shall be marked for repair. Defective seams shall be repaired by hot wedge welding. If the location of the defective seam prevents hot wedge welding, an air leister gun shall be used.

C Discrepancies shall be noted and repaired at no additional expense. Final acceptance of the system shall be contingent upon the approval of the Engineer.

END OF SECTION

SECTION 02272

FILTER FABRIC

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install filter fabric complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill and Compaction

B Section 02290: Protective Cover

C Section 02276: Erosion and Sedimentation Control

D Section 02274: Geocomposite Drainage Net

E Section 02505: Crushed Stone Paving

1.03 SUBMITTALS

A At least 30 calendar days prior to filter fabric installation, submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. List of material properties and samples of filter fabric with attached certified test results.

3. Manufacturer's quality control program and manual including description of laboratory facilities.

4. A list of ten completed facilities where the filter fabric is used including:

   a. Name and purpose of facility, its location and date of installation.

   b. Name of Owner, project manager, design engineer and installer.

   c. Fabric thickness and surface area.

   d. Specific application and information on performance of the facility.

5. Shop Drawings, including:

   a. Proposed panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings, if applicable.

   b. Details of overlap, seaming, anchoring, connections and other construction details.

6. Installation schedule and locations of areas designated for installation

7. A manual that specifically defines the quality control and quality assurance program during installation including manufacturer's installation guidelines.

8. Copy of quality control certificates in conformance with Paragraph 2.02.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D5199 - Standard Test Method for Measuring Thickness of Textile Materials.

2. ASTM D5261 - Standard Test Method for Mass per Unit Area (Weight) of Woven Fabric.

3. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.

4. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

5. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

6. ASTM D4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).

7. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.

8. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 FABRIC APPLICATIONS

The filter fabric is to be used for placement beneath erosion control stone and structures, beneath crushed stone paving where called for and bonded to both sides of drainage net for geocomposite. The unit weights of the filter fabric for each use are specified herein.

1.06 DELIVERY, STORAGE AND HANDLING

A The filter fabric shall be shipped, stored and handled in accordance with manufacturer's recommendations and as specified herein.

B The fabric shall be stored with a cover so that it is protected from exposure to sunlight and shall be elevated from the ground (a minimum of 3-in) to protect the fabric from stones and other sharp objects and saturation.

1.07 REQUIREMENTS PRIOR TO INSTALLATION

A For use in erosion control structures, the subgrade shall be inspected and approved by the CQA Officer (RPR) prior to installation of the filter fabric. The subgrade shall be smooth, uniform and compacted for the installation of the fabric.

B During the leachate collection system installation whereas a trench is excavated in the sand or drainage layer, the area shall be inspected and approved by the CQA Officer prior to installation of the filter fabric to ensure against damage to the drainage net and liner system.

C Prior to installation of the geocomposite, the material shall be inspected and conformance tested by the CQA Officer and Quality Assurance Laboratory to ensure the filter fabric is sufficiently bonded to the net.

1.08 MATERIAL WARRANTY

A The manufacturer shall warrant the material, against manufacturing defects and material degradation for a period of five years from the date of installation. The manufacturer shall replace any material which fails within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the filter fabric against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A Nonwoven Fabric

1. All fabric shall be a nonwoven needle punched polypropylene fabric consisting of filaments formed into a stable network, such as SKAPS GE-160 or equal.

2. A nominal 8 oz/yd^2 unit weight fabric shall be used as bedding for rip-rap lined stormwater structures, ditches and outlets. The 6 oz/yd^2 unit weight fabric shall be heat bonded to both sides of the drainage net as specified in Section 02274.

3. The fabric shall be non-biodegradable, nonreactive within a pH range of 2 to 13, resistant to ultraviolet light exposure, and resistant to insects and rodents. Test results from any sampled roll in the lot, when tested in accordance with ASTM D4759, shall meet or exceed the values listed in Table 1.

TABLE 1
MINIMUM AVERAGE ROLL VALUES (MARV)
GEOTEXTILE FABRICS

PROPERTIES	TEST METHOD	MARV		
		UNIT	6 OZ.	8 OZ.
Fabric Weight	ASTM D5261	oz./yd2	5.7	7.3
Thickness	ASTM D1777	mils	80	90
Grab Tensile Strength	ASTM D4632	lbs	150	205
Grab Elongation	ASTM D4632	%	50	50
Puncture Resistance	ASTM D4833	lbs	85	110
Mullen Burst Strength	ASTM D3786	PSI	220	320
Permittivity	ASTM D4491	gal/min/ft^2	110	110
Apparent Opening Size	ASTM D4751	US Sieve	70	80

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered fabric.

1. Each roll delivered to the Project site shall have the following identification information:

   # Manufacturer's name
   # Product identification
   # Thickness
   # Roll number
   # Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At a minimum the following test results shall be provided every 50,000 square feet of manufactured fabric in accordance with test requirements specified in Paragraph 2.02.

   # Thickness
   # Grab Tensile Strength
   # Grab Elongation
   # Puncture Resistance

Mullen Burst Strength

2.04 CONFORMANCE TESTING

A Conformance testing may be performed at the discretion of the CQA Officer. An independent Quality Assurance Laboratory (QAL) approved by the Owner will test samples obtained by the CQA Officer from the material proposed. The machine direction and identification number will be identified. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Contractor shall perform conformance testing on the initial roll at the Contractor's expense. The samples shall be taken across the entire roll width and shall not include the first 3-ft. The following conformance tests shall be conducted at the laboratory.

1. Mass per unit area (ASTM D5261)
2. Mullen burst strength (ASTM D3786)
3. Puncture resistance (ASTM D4833)
4. Grab tensile (ASTM D4632)
5. Permittivity (ASTM D4491)
6. Apparent opening size (ASTM D4751)

B These conformance tests shall be performed in accordance with test requirements Paragraph 2.02.

C All conformance test results shall be reviewed by the CQA Officer and accepted, prior to the deployment of the fabric. All test results shall meet, or exceed, the property values listed in Paragraph 2.02.

D The manufacturer may obtain samples from rolls manufactured immediately before and after the failing roll and request testing by the QAL at the manufacturer's expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot will be rejected.

E The cost of a first-run conformance testing shall be borne by the Owner and shall be performed by the CQA Officer or his/her representative and an independent Quality Assurance Laboratory (QAL) selected by the Owner. If the fabric fails the first-run unit conformance tests, the contractor shall pay for the cost of subsequent conformance testing until all conformance tests are passed and the fabric is accepted by the CQA Officer.

PART 3: EXECUTION

3.01 PREPARATION

A General

1. Preparation of the subgrade shall be in accordance with Section 02200, Section 02777, depending on the specific application.

2. The subgrade shall be inspected by the CQA Officer (RPR) prior to installation of the filter fabric.

3.02 INSTALLATION

A Fabric Placement

1. The subgrade shall be maintained in a smooth, uniform and compacted condition during installation of the filter fabric beneath the erosion control stone.

2. No mechanical equipment shall be driven directly on top of the filter fabric.

3. Granular fill materials shall be installed in accordance with Section 02700.

4. Erosion and drainage layer cover shall be placed with mechanical equipment; however, no mechanical equipment shall be allowed directly on top of the filter fabric. Equipment shall be driven on pre-deposited material.

5. Erosion and drainage layer cover shall be brought to the work area with earth-carrying equipment, deposited on the previously spread soil cover (minimum of 2-ft. thick), then pushed onto the uncovered portion of the filter fabric with bulldozers or excavator loaders.

6. Protective cover soils, erosion and drainage layers for the side slopes of the filter fabric shall be placed at the bottom and pushed uphill to reduce any tension in the fabric or underlying 40 mil textured LLDPE liner.

7. Damage to the filter fabric occurring during the placement of protective cover shall be repaired immediately at no additional expense to the Owner.

B Field Overlap

1. The fabric shall be overlapped according to the manufacturers recommended installation guidelines for a particular application.

3.03 FIELD QUALITY CONTROL

A Two duplicate documentation files for fabric placement shall be maintained. One shall be maintained by the Contractor and the other by the Engineer. At the end of each work week, the files shall be updated and checked to assure that all copies of pertinent project information are included in each file. The Contractor shall submit daily copies of the documentation to the Engineer.

B The filter fabric installation and related work shall be inspected by the Engineer. All work in the system therein being inspected shall be complete, clean and ready for use. All work shall meet the requirements of cleanliness and workmanship, as determined by the Engineer.

C Discrepancies shall be noted and repaired at no additional expense. Final acceptance of the system shall be contingent upon the approval of the Engineer.

END OF SECTION

SECTION 02274

GEOCOMPOSITE DRAINAGE NET

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install geocomposite drainage net consisting of high quality polyethylene (HDPE) drainage net with nonwoven filter fabric bonded to both sides in the locations shown on the Drawings and as specified herein. [Note: Specifications for the nonwoven filter fabric that is bonded to both side of the drainage net are included in Section 02272.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill and Compaction

B Section 02700: Protective Cover

C Section 02701: Drainage and Erosion Layer

D Section 02272: Filter Fabric

E Section 02276: Compacted Soil Liner

F Section 02280: Infiltration Layer

G Section 02776: Textured High Density Polyethylene (HDPE) Liner.

H Section 02777: Textured Linear Low Density Polyethylene (LLDPE) Liner.

1.03 SUBMITTALS

A At least 60 prior to geocomposite drainage net installation submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. List of material properties and samples of geocomposite drainage net with attached certified test results.

3. Manufacturer's quality control program and manual including description of laboratory facilities.

4. A list of ten completed facilities where the geocomposite drainage net is used including:

   a. Name and purpose of facility, its location and date of installation.

   b. Name of Owner, project manager, design engineer and installer.

   c. Geocomposite drainage net thickness and surface area.

   d. Information on performance of the facility.

5. Shop Drawing, including:

   a. Proposed panel layout or plan showing the installation layout identifying field seams as well as any variance or additional details that deviate from the Drawings.

   b. Details of overlap and seaming of the geocomposite drainage net, anchoring, connections and other reconstruction details.

6. Installation schedule.

7. A manual that specifically defines the quality control and quality assurance program during installation including manufacturer's installation instructions.

8. Copy of quality control certificates in conformance with Paragraph 2.02.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

2. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

3. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

4. ASTM D1777 - Standard Method for Measuring Thickness of Textile Materials.

5. ASTM D3776 - Standard Test Method for Mass Per Unit Area (Weight) of Woven Fabric.

6. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In Plane Flow) of Geotextile and Geotextile Related Products.

7. ASTM D751 - Standard Method for Testing Coated Fabrics

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DELIVERY, STORAGE AND HANDLING

A The drainage net shall be shipped, stored and handled in accordance with manufacturer's recommendations.

B The geocomposite drainage net shall be stored such that it is protected from exposure to sunlight and it shall be elevated from the ground (a minimum of 3-in) to protect the geocomposite drainage net from puncture and soil staining.

1.06 PROJECT/SITE REQUIREMENTS

A The underlying geomembrane material shall be inspected and found acceptable by the CQA Officer (RPR) prior to installation of the geocomposite drainage net.

1.07 MATERIAL WARRANTY

A The geocomposite drainage net manufacturer shall warrant the material, against manufacturing defect and material degradation (prorated basis) for a period of five years from the date of installation. The manufacturer shall replace any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.08 GUARANTEE

A The Contractor shall guarantee the drainage net against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide planar water flow.

B A geotextile filter fabric shall be heat bonded to both sides of the drainage net. Heat bonding shall be performed by the manufacturer prior to shipping to the site. The geotextile filter fabric shall be 6 oz/yd^2 nonwoven needle punched polypropylene fabric as specified in Section 02272 (QC testing for the geotextile is specified therein).

C The geocomposite drainage net shall contain UV inhibitors.

D The geonet and geocomposite shall conform to the following minimum properties:

Property	Test Method	Required Value
Density	ASTM D1505	0.940 g/cm^2
Melt Flow Index (Condition 0/2.16)	ASTM D1238	1.0 g/10 min. (max)
Carbon Black Content (Net)	ASTM D4218	2.0%
Thickness	ASTM D5199	200 mils
Tensile Strength	ASTM D5035	45 lbs/in
Ply Adhesion	ASTM 7005	1.0 lb/in.
Transmissivity [1]	ASTM D4716	2.5 x 10^{-5} m^2/s
Transmissivity [2]		3.5 x 10^{-5} m^2/s

Notes: [1] Transmissivity measured using water at 21 +/- 2° C (70 + 4° F) with a gradient of 0.1 and a confining pressure of 2088 psf between steel plates after 15 minutes.
[2] Transmissivity measured using water at 21 +/- 2° C (70 + 4° F) with a gradient of 0.1 and a confining pressure of 208 psf between steel plates after 15 minutes.

E Geocomposite drainage net shall be SKAPS TRANSNET 220-2-6 or equal.

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation of any drainage net material, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered drainage net.

1. Each roll delivered to the Project site shall have the following identification information:

Manufacturer's name

Product identification
Thickness
Roll number
Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At a minimum the following test results shall be provided every 50,000 square feet of manufactured drainage net in accordance with test requirements specified in Paragraph 2.02.

Resin Density
Melt Flow Index
Thickness
Carbon Black Content
Tensile Strength
Ply Adhesion
Transmissivity

2.04 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. CQA Representative shall obtain samples from the delivered material, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Contractor shall pay for conformance testing on the initial roll at the Contractor's expense. The samples shall be taken across the entire roll width and shall not include the first 3-ft. The following conformance tests shall be conducted at the laboratory:

1.	Resin Density	(ASTM D1505)
2.	Carbon Black Content	(ASTM D1603)
3.	Melt Index	(ASTM D1238)
4.	Thickness	(ASTM D5199)
5.	Transmissivity	(ASTM D4716)
6.	Mass per Unit Area	(ASTM D3776)

B These conformance tests shall be performed in accordance with test requirements specified in Paragraph 2.02.

C All conformance test results shall be reviewed by the Engineer and accepted or rejected, prior to the deployment of the geocomposite drainage net. All test results shall meet, or exceed, the property values listed in Paragraph 2.02. In case of failing test results, the Contractor may request that another sample be retested by the QAL with manufacturer's technical representative present during the testing procedures. The costs for retesting including engineering, analyses and all associated expenses shall be paid for by the Contractor. The Contractor may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted; if both laboratories do not report passing results, all material from the lot representing the failing sample will be considered out of specification and rejected. The manufacturer may obtain additional samples from rolls immediately before and after the failing roll or as directed by the Engineer and have them tested by the QAL at his/her own expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot will be rejected.

PART 3: EXECUTION

3.01 PREPARATION

A General

Prior to installation, the following actions shall occur:

1. The underlying liner or geomembrane shall be swept clean of debris, waste material, equipment, and other miscellaneous objects.

2. The underlying liner or geomembrane shall be inspected by the CQA Representative and the installer prior to installation of the drainage net to check for damage such as; tears, punctures, scratches, and defects.

3. The CQA Officer shall confirm with the installer that all seams and patches have been tested and approved and that all necessary survey information has been obtained.

3.02 INSTALLATION

A Panel Placement

1. Care shall be taken to keep the geocomposite drainage net clean and free from debris prior to installation.

2. The geocomposite drainage net shall be installed in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with during installation:

a. Geocomposite drainage net shall be anchored as shown on the Drawings.

b. On slopes, the geocomposite drainage net shall be secured and rolled down the slope in such a manner as to continually keep the geocomposite drainage net sheet in tension. If necessary, the geocomposite drainage net shall be positioned by hand after being unrolled to minimize wrinkles.

c. In order to protect against wind uplift, all geocomposite drainage net shall be weighted with sandbags or by other means. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

d. Geocomposite drainage net shall only be cut using scissors or J-hook blades. Care shall be taken not to leave tools on the drainage net.

e. Necessary precautions shall be taken to prevent damage to underlying layers during placement of the drainage net.

f. During placement of geocomposite drainage net, care shall be taken not to entrap soil in the geocomposite drainage net or stones that could damage the underlying liner. If soil is entrapped in the drainage net, it should be hosed clean or replaced. In this regard, care shall be taken in handling the sandbags, to prevent rupture of the sandbag.

B Field Seams and Overlaps

1. The following requirements shall be met during installation of the drainage net:

a. The geocomposite drainage net of adjacent panels shall be overlapped by at least 4-in. For end widths of panels, the geocomposite drainage net shall overlapped a minimum of 4-inches with the upslope panel placed over the downslope panel.

b. Seams shall be secured by tying. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be a color that contrasts with black for easy inspection. Metallic devices are not allowed.

c. Tying shall be every 5-ft along seams, at minimum.

d. The unbonded fabric on the top side of the geocomposite drainage net shall be sewn or hot-wedge welded along side seams of adjacent panels.

e. For end width seams and patches, a 24-inch strip of fabric shall be placed over the seam and held in place with soil.

f. Horizontal seams on 4 to 1 slopes shall not be allowed unless it is demonstrated to the CQA Officer that it is absolutely necessary.

3.03 FIELD QUALITY CONTROL

A Two duplicate documentation files for panel placement shall be maintained. One shall be maintained by the Contractor and the other by the CQA Officer. At the end of each work week, the files shall be updated and checked to assure that all copies of pertinent project information are included in each file. The Contractor shall submit daily copies of the documentation to the CQA Officer.

B Any holes or tears in the geocomposite drainage net shall be repaired by placing a patch extending 1-ft beyond the edges of the hole or tear. The patch shall be secured to the original geocomposite drainage net by placing ties every 6-in. Tying devices shall be as specified in Paragraph 3.02B. All repairs and patches shall be approved by the CQA Officer.

C Damage to the geocomposite drainage net occurring during the placement of the material overlying the geocomposite drainage net shall be repaired immediately at no additional expense to the Owner.

3.04 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

END OF SECTION

SECTION 02275

COMPACTED SOIL LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install compacted soil liner with a maximum in-place permeability of 1.0×10^{-5} cm/s of 18-inch minimum thickness as measured perpendicular to the slope as shown on the Drawings and as specified herein. Associated work includes quality control testing, borrow source excavation, hauling, screening, constructing a test pad, placement, moisture conditioning, harrowing, compaction, and grading of natural soil or soil-bentonite materials for bottom liner construction in the disposal unit.

1.02 RELATED WORK

A Section 01040: CQA Plan

B Section 01050: Field Engineering

C Section 02200: Excavation, Backfill and Compaction

D Section 02776: Textured High Density Polyethylene (HDPE) Liner.

1.03 SUBMITTALS

A At least 45 days prior to test pad construction, the Contractor shall submit the following information in accordance with Section 01340:

1. Identification of the compacted soil liner type (natural soil or Contractor-prepared soil-bentonite mix.)

2. If a natural soil is proposed, submit the following documentation:

   a. Name and location of the proposed natural soil borrow source,

   b. Test results and other documentation as necessary to verify that the proposed natural soil meets the requirements of 2.01A of this Section, and

   c. Anticipated volume of suitable natural soil available to the project.

3. If a soil-bentonite mixture is proposed, submit the following documentation:

a. Name and location of the proposed soil source,

b. Test results and other documentation as necessary to verify that the proposed soil meets the requirements of 2.01B of this Section,

c. Name and location of the bentonite supplier,

d. Test results and other documentation as necessary to verify that the proposed bentonite meets the requirements of 2.01C of this Section,

e. Anticipated bentonite application rate, and

f. Manufacturer's literature describing the pugmill to be used for preparing the soil-bentonite mix.

4. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

5. A description and schedule of the installation procedure and a list of installation equipment.

6. A Construction Quality Control (CQC) Plan for the compacted soil liner installation including:

a. Names and qualifications of the construction quality control firm and laboratory including the CQC Officer to be retained by the Contractor

b. Number, names and qualifications of CQC field personnel.

c. CQC procedures for borrow excavation and test pad construction.

d. CQC procedures for installation including exclusion and removal of oversized particles and organic matter from the compacted soil liner material, moisture control, placement, mixing, compaction and lift thickness control.

e. Site plan or map with 1-acre grid blocks to track and demonstrate field Quality Control testing described in Paragraph 3.04 of this Section.

f. Procedure for protection of liner from adverse weather conditions (precipitation, frost, or intense heat) and all other relevant procedures.

7. Experience and performance credentials, resumes, etc. in conformance with Paragraph 1.06A.

8. Samples from the material source to be used in the liner installation, to be collected by CQC.

9. Subgrade elevations in a form acceptable by the Engineer.

B. At least 21 calendar days prior to test pad construction, submit the results of testing conducted by CQC that demonstrates the proposed compacted soil liner material meets the requirements of Paraqraphs 2.01A and 2.01B.

C. At least 21 calendar days prior to test pad construction, submit at least 100 lbs of the proposed compacted soil liner material contained in sealed 5-gallon pails and at least a 10 sf. section of the approved textured high density polyethylene (HDPE) liner (Section 02776) to the Engineer.

1.04 REFERENCE STANDARDS

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer Than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2937 - Standard Test Method for Density of Soils in Place by the Drive-Cylinder Method.

10. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

13. ASTM D4767 - Test method for Consolidated - Undrained Triaxial Compression Test on Cohesive Soils.

14. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

15. ASTM D5321 - Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic friction by the Direct Shear Method.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A The Owner will retain a geotechnical CQA Officer who is experienced in the construction of compacted soil liners. The CQA Officer and his/her representatives shall observe the Contractors work and perform tests as specified to provide assurance that the liner meets the requirements of this specification.

B The Contractor will retain an independent geotechnical CQC Officer that is experienced in the construction of compacted soil liners and who is capable of performing the tests specified herein and who has sufficient hydraulic conductivity testing equipment to provide test results in a timely manner (5-7 days) in accordance with the Specification. The CQC Officer shall provide direction and testing as necessary to control the quality of the borrow material (material property requirements specified in Paragraphs 2.01A and B) mixing procedures and thoroughness, bentonite application rate, moisture control for the pugmill operation, and proper construction of the test pad and the compacted soil liner.

C An "acceptable zone" and testing shall be submitted as detailed in Section 2.02C by the CQC Officer.

D After the acceptable zone testing has been performed and approved by the CQA Officer, a test pad shall be constructed on site using the same equipment and installation procedures that will be used during full-scale liner construction.

The purpose of the test pad is to assure that the construction procedures proposed for full scale liner installation will produce an acceptable liner. Construction requirements and testing procedures for the test pad are specified in Paragraph 3.01.

1.06 QUALIFICATIONS

A The work shall be performed by personnel that have demonstrated experience in processing and installation of a low permeability soil liners.

1.07 DELIVERY, STORAGE AND HANDLING

A Materials may be stockpiled on-site in designated approved areas. Each type of material shall be stockpiled separately. Removal and placement of material shall be done in a manner to minimize mixing with soils adjacent to and beneath the stockpile.

B If a soil-bentonite mixture is used, both the stockpiled soil to be used in the mix and the soil-bentonite mixture, if stockpiled, shall be sealed or covered with an impermeable cover at the end of each day and during rain events.

C The bentonite storage sites should be cleared and level. Bentonite material shall be contained and covered to preserve the fitness and quality of the material.

D The Contractor shall protect the natural soil or the soil-bentonite mixture materials delivered to the site from inclement weather conditions and any traffic that may occur near the stockpile.

PART 2: PRODUCT

2.01 MATERIALS

A Compacted soil liner materials, **whether natural soil or soil-bentonite mixtures**, shall conform to the properties listed in Table 1:

TABLE 1

PROPERTY	TEST METHOD	REQUIREMENT
Passing the 1.5-inch Sieve (%)	ASTM D422	100% minimum
Passing the 10 Sieve (%)	ASTM D422	90% minimum
Passing the 200 Sieve (%)	ASTM D1140	35% minimum
Liquid Limit	ASTM D4318	40% minimum
Plasticity Index	ASTM D4318	15% minimum
USCS Soil Classification	ASTM D2488	CH, CL, MH, ML, SC
Hydraulic Conductivity	ASTM D5084	$1.0x10^{-5}$ cm/s maximum
Interface Effective Friction Angle (w/Textured HDPE)	ASTM D5321	24° minimum, or as approved by the ENGINEER
Internal Effective Friction Angle	ASTM D4767	24° minimum, or as approved by the ENGINEER
Organic Content	ASTM D2974	3% maximum

B If a soil-bentonite mixture is used for the compacted soil liner, the soil to be used for the mixture shall consist of a natural mineral soil that is free from fill materials, organic materials, loam, wood, trash, snow, ice and other objectionable materials and shall conform to the properties in Table 1:

C If a soil-bentonite mixture is used for the compacted soil liner, the bentonite used in the mixture shall be a free flowing, high swelling, sodium-based, Wyoming bentonite. The bentonite shall conform to all items of this specification. Certified test data shall be submitted to the Engineer for approval. The requirements are as follows:

1. The bentonite shall meet the contamination resistance criterion defined as the ability of the bentonite, when pre-hydrated with fresh water for a minimum of 72 hours, and tested at the rate of 2.5 lbs. per square foot mixed into a 2-inch layer of SP type sand to maintain hydraulic conductivity for a minimum of 200 days after introduction of a solution containing 3% ammonium chloride into the testing device, or equivalent certification that meets the approval of the Engineer.

2. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D The natural soil or soil-bentonite mixture material proposed for liner construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0×10^{-5} cm/s or less based on testing according Paragraph 3.01H.

E If a soil-bentonite mixture is used for the compacted soil liner, the soil-bentonite blending shall be accomplished using a pugmill and the Contractor shall demonstrate to the satisfaction of the Engineer that the proposed blending method will produce a consistent end product.

F. The Contractor shall show evidence of an adequate, homogenous supply of material within a designated area which is properly permitted by the appropriate local, State and Federal agencies.

2.02 CONFORMANCE TESTING

A Initial conformance testing shall be performed by CQC on samples from the natural soil source, or soil source for a soil-bentonite mixture, to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of CQC. The following tests shall be performed on the samples. For soil to be used in a soil-bentonite mix, tests 5, 8 and 9 are to be performed on the soil-bentonite mixture. Normal stresses representing field conditions should be used for the internal and interface shear tests. The effective and total shear strength friction angle should be reported.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) – *including hydrometer analysis*
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Relationship Curves (ASTM D698)
5. Laboratory Hydraulic Conductivity (ASTM D5084, except as modified in Paragraph 3.01H)
6. Natural Moisture (ASTM D2216)
7. Specific Gravity (ASTM D854)
8. Shear Tests for compacted soil liner material (ASTM D4767 or as approved by the Engineer)
9. Interface Shear Tests (soil/synthetic liner or soil-bentonite/synthetic liner) – *using a direct shear, rotational shear, or as approved by Engineer*

B If a soil-bentonite mixture is proposed for the compacted soil liner, the Contractor shall be responsible for establishing the percentage of bentonite to be used for the test pad construction based on the results of laboratory testing conducted by CQC specified in 2.02A, above, on the soil-bentonite mixture. This testing shall be completed with the results furnished to the Engineer at least 21 calendar days prior to beginning test pad construction.

C For natural soil sources, the CQC Officer shall determine an acceptable zone of moisture contents and dry unit weights for which permeabilities are less than or equal to $1.0x10^{-5}$ cm/s by performing the following testing and analysis procedures:

1. Using the samples extracted from the proposed soil source, perform a Standard Proctor compaction test to develop a moisture-density curve for a representative sample of material. Use five specimens at incremental moisture contents to develop the compaction curve showing dry density for each molding water content.

2. Permeate compacted specimens, compaction to different moisture contents and densities, to determine their hydraulic conductivity. The compacted soil liner shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698

3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to $1.0x10^{-5}$ cm/s.

4. Draw an "acceptable zone" of water content and dry density around the passing samples.

5. Perform Internal Shear Tests (ASTM D4767) and Interface Shear Tests (ASTM D5321 and Paragraph 2.01E) on one specimen of the compacted soil liner material. The sample for each test should be remolded wet of the optimum moisture content and within the acceptable zone for the percent compaction and the moisture content that is anticipated for construction. The CQA Officer may require additional internal shear tests and interface shears tests if the compacted soil liner's proposed placement moisture content and percent compaction differs substantially from the shear test result's moisture content and percent compaction presented above. Additional shear strength tests will be at the cost of the Contractor.

   For Internal Shear Tests (ASTM D4767), use the following parameters:

   A. Strain rate/shear rate required: As recommended in ASTM D4767

   B. Consolidation pressures required: 1.5 psi, 5 psi, 40 psi

   C. Consolidation/seat time for samples: As recommended in ASTM

D4767

For Interface Shear Tests (ASTM D5321), use the following parameters:

A. Strain rate/shear rate required: See ASTM D5321, Paragraph 8.2 and Paragraph 11.6. Due to varying soil types, if strain rate adjustments to the above referenced Paragraphs are required due to pore pressure dissipation problems, submit recommended adjustments for review by Engineer.

B. Normal stresses required: 1.5 psi, 5 psi, 40 psi

C. Consolidation/seat time for samples: As recommended in ASTM D5321, typically, 16-24 hours per normal stress application prior to initiating shear rate

6. Based on the shear test results and other pertinent factors such as constructability, shrink/swell potential, potential for desiccation cracks, and consolidation, the CQC Officer shall modify the acceptable zone as required.

7. CQC shall provide the graphs described above to the Contractor. If additional sources are used, the tests described above shall be performed by the CQC and the costs will be paid by the Contractor.

D For soil-bentonite mixes, once the Contractor has selected the bentonite application rate and completed the testing and submitted the test data and results as indicated in 2.02B, above, CQC shall perform the acceptable testing described in 2.02C above, prior to constructing the test pad.

E The natural soil or soil (for soil-bentonite mixture) source shall be tested by the CQC at the frequencies stated in Table 2. If changes in material, as identified by the CQA Officer or CQC representative, occur within the frequency prescribed below, additional tests shall be performed at the expense of the Contractor.

TABLE 2

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	Every 2,500 cy
Atterberg Limits	ASTM D4318	Every 2,500 cy
Moisture/Density	ASTM D698	Every 5,000 cy
Natural Moisture	ASTM D2216	Every 2,500 cy

Results of the tests shall be submitted to the CQA Officer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 TEST PAD

A A test pad of a dimension of no less than 40-ft by 60-ft and 18-inch thickness shall be constructed on-site using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The compacted soil liner material to be used for the test pad shall be the same material that the Contractor proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the liner limits and incorporated in the work, provided the pad passes all testing requirements. Test pad soils tests shall be independent of and not be included in the full-scale soil liner testing results.

B The construction of the pad shall be directed by the CQC Engineer. The CQC Engineer shall use the acceptable zone established to set moisture contents and percent compaction. CQC shall perform tests as needed to assist in the construction of the test pad. Both the CQC and CQA field and laboratory testing will be evaluated for determining the performance of the test pad

C The compacted soil liner in the test pad shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

D The final compacted thickness of each lift shall be a maximum 6" lift thickness. For each lift, the CQC shall perform testing of moisture content and density at a minimum of three test locations. Two thin-wall tube samples shall be obtained per lift by the CQC. One tube will be used to perform a permeability test. The second tube will be kept as a backup in case of damage to the first sample.

E If the initial test pad does not provide the specified results, additional test pad(s) shall be performed, at the Contractor's cost (including CQA costs), until the specified requirements are met.

F For compacted soil liner consisting of a soil-bentonite mix, the bentonite content used for the test pad shall be set by the Contractor and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

G The Contractor may construct test pads for more than one source of compacted soil liner material or soil-bentonite mix ratios. However, only one

test pad will be tested and evaluated at the Owner's cost as a part of the specified construction quality assurance (CQA). All costs associated with subsequent test pads shall be paid for by the Contractor. If the Contractor changes the source of natural soil or soil (for the soil-bentonite mixture) or if the characteristics of the natural soil or the soil within the selected source changes significantly, the Engineer may order the construction of additional test pads and subsequent tests as specified above as may be necessary to evaluate the performance of the compacted soil or soil-bentonite liner. Construction of additional test pads and the related CQA work shall be paid for by the contractor.

H One triaxial hydraulic conductivity test (ASTM D5084) will be performed on each lift of the test pad. These tests will be performed on undisturbed thin-wall tube samples collected by CQC in accordance with ASTM D1587. The samples shall be trimmed if needed, encapsulated within a flexible latex membrane, and mounted in permeameters conforming to the requirements of ASTM D5084. Each test specimen shall be consolidated under an effective stress of 8 to 12 psi and permeated under a backpressure as recommended in paragraph 8.3 of ASTM D5084 to achieve saturation. The maximum hydraulic gradient across the sample shall not exceed thirty (30) as per paragraph 8.5.1 of ASTM D5084 or as specified by Engineer. The hydraulic gradient shall be increased slowly in increments with careful observations of the test sample for consolidation, piping, etc. Test samples that are consolidated in volume by more than 5 percent during the test shall be voided. The inflow and outflow from the sample shall then be monitored and the hydraulic conductivity calculated for each recorded flow increment. The tests will continue until steady state flow is achieved as specified in paragraph 8.5 of ASTM D5084.

I The compacted soil liner thickness shall be determined from three test locations per lift selected by CQC per test pad using a method consisting of hand augering or push tube sampling (with a minimum of a 3/4" diameter sample) or as approved by the Engineer. Holes in the compacted soil liner shall be backfilled by the Contractor with dry powdered or chipped bentonite.

3.02 SUBGRADE PREPARATION

A The subgrade shall be graded to elevations in accordance with the plans.

B The compacted soil liner subgrade shall be proofrolled by the Contractor in accordance with Section 02200 and examined by the CQA Officer and/or the RPR to detect unstable or loose soils. Based on observation during the proofrolling operation, the CQA Officer and the RPR reserves the right to select the number and direction of passes to be used. Any unsuitable soils encountered at subgrade elevation shall be removed and replaced as directed by the CQA Officer and/or the RPR at no additional cost to the Owner.

C The subgrade surface shall not be smooth rolled. The subgrade surface shall be left in a roughened condition to allow good adherence between the subgrade and the initial lift of the compacted soil liner.

D The CQA Officer shall observe and approve the subgrade and the survey plan of subgrade elevation submitted by the Contractor before installation of the compacted soil liner can proceed. It shall be the Contractor's responsibility to properly prepare and maintain the subgrade in a uniform and compacted condition during installation of the liner.

E If the subgrade is damaged during liner installation, the Contractor shall restore and re-compact the area; CQC shall re-test the subgrade in accordance with ASTM D1556, D2922, or D2937 prior to installing the liner. All costs related to the re-test and restoration of the subgrade shall be paid for by the Contractor.

3.03 SOIL OR SOIL-BENTONITE LINER PLACEMENT

A The CQC Officer and his/her site representatives shall supervise the liner installation. Work shall not be performed by the Contractor without the CQA Officer and/or the RPR onsite. CQA and CQC shall perform field tests (i.e. moisture content, densities, etc.) as required to ensure proper installation. CQA and CQC shall perform tests as described in section 3.04 to determine acceptance of the in-place liner.

B. The compacted soil liner material shall be compacted to a dry density equal to or greater than 95 percent of its maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

C The placement moisture content shall be within the acceptable zone of moisture content as determined by the CQC Officer during the conformance testing of the natural soil or soil-bentonite mixture described in paragraph 2.02C. The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

D Water for Construction of the Soil Liner

1. The Contractor shall provide water as required to achieve the required moisture content, unless otherwise specified in the Contract Documents.

2. The water shall be from an approved source.

3. Prior to installing the liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the compacted soil liner material be stockpiled for any length of time, the Contractor shall slope, seal and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper percentage.

E The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content or 95 percent of its maximum dry density, whichever is greater. The acceptable zone shall be as specified by the CQC Officer in accordance with the procedures outlined in 2.02C. Density shall be uniformly obtained throughout the entire thickness of the liner. The compacted soil liner shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift. The surface of a lower lift shall be scarified, if needed, prior to placement of an upper lift. During placement of the initial lift care should be taken to avoid mixing of the liner material and subgrade material.

F To achieve the specified compaction the Contractor shall use a self-propelled compactor equipped with steel kneading feet capable of fully penetrating the loose lift and into the previously compacted lift. A smooth wheel compactor shall be used with sufficient number of passes to smooth the upper surface of the compacted soil liner. A smooth wheel compactor shall be used only for final smoothing of the surface and not be used for achieving the specified compaction.

G Liner material shall be disced, harrowed, and kneaded as necessary to break down all clods and produce a uniform material that is free of clods. A clod is defined for the purposes of construction as any subrounded ball of soil exceeding 1/2" in diameter, typically with the core containing less than the specified moisture. If the CQA Officer and/or the RPR observe that all clods have not been broken down, the Contractor shall rework the material to the satisfaction of the CQA Officer and/or the RPR.

H Liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated soil materials.

I In the case of soil-bentonite mix for the compacted soil liner, the Contractor shall use a pugmill to blend the soil-bentonite mix at the required moisture content. Soil borrow material to be used for soil-bentonite compacted soil liner construction shall be shredded and screened by power methods to provide a uniform soil free of roots, stumps, and other organic materials, rocks, and debris and to provide particle sizes to be used in the compacted soil liner less than 1.5 inches in its longest dimension for natural soil and 1.5 inches in its longest dimension for soil-bentonite mixes.

J For the final lift, the contractor shall employ a crew of laborers to remove all rocks 1-inch or larger prior to smooth rolling.

K No liner material shall be placed, spread, or compacted while the ground or the liner material is frozen or thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The liner surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the liner material. Any regrading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift or HDPE liner. Thickness measurements should be performed as indicated in Section 3.04 A. Areas previously meeting the conformance test requirements that are reworked in excess of the top 3-inch per lift shall be retested. Retesting will be at the cost of the Contractor.

L Should desiccation cracks develop, the liner shall be scarified, disced, rewetted, re-homogenized and re-compacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer and/or the RPR. If desiccation extends below half of the lift thickness, the entire lift shall be reworked and retested as described above. Retesting will be at the expense of the Contractor.

M During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the liner system and for moisture control and protection of the compacted soil liner.

N After finish grading and smooth rolling is completed, the compacted soil liner shall not be less than 18-inches in any location. Liner thickness will be tested by CQA and CQC personnel on a per lift basis at a frequency specified in 3.04A using a method of hand augering or push tube sampling (minimum 3/4" sample). This testing is primarily to estimate liner lift thickness and shall not be used to verify total dry liner thickness. The final compacted soil liner thickness will be determined from the Contractor's survey. Areas not meeting the thickness requirements shall be augmented with additional soil material. The Contractor's surveyor shall be available to assist in determining the areal extent of compacted soil liner that is not at least 18-inches thick. Any additional testing or CQA services associated with corrective action for achieving the 18-inch liner thickness requirement will be at the cost of the Contractor. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 3-inches of the liner shall be wetted, kneaded, compacted and re-worked with the additional material to obtain the required thickness.

3.04 QUALITY ASSURANCE DURING PLACEMENT

A The CQC/CQA personnel shall conduct tests during installation of the compacted soil liner at the minimum frequencies specified in Table 3. The CQC Officer will provide direction and testing as necessary to the Contractor to control quality of the compacted soil liner materials to meet the specifications listed in Section 2.01; however, the results of CQC and CQA testing will both be considered in accepting or rejecting compacted soil liner materials.

TABLE 3

TEST	METHOD	FREQUENCY	
		CQC	CQA
Grain Size w/Hydrometer	ASTM D422	1/acre/lift	1/acre
Atterberg Limits	ASTM D4318	1/acre/lift	1/acre
Undisturbed Permeability	ASTM D5084	1/acre/lift	1/two acres
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	4/acre/lift	2/acre
Natural Moisture[1]	ASTM D2216 ASTM D3017 ASTM D1556	4/acre/lift (at density location)	2/acre
Liner thickness	Hand Auger or push tube	4/acre/lift	N/A

B The minimum testing frequencies for field tests to be performed by the Contractor's Quality Control personnel and the Owner's Quality Assurance personnel are identified in Sections 3.04. A. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per

day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

C All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the Contractor and/or CQC Officer with dry powdered or chipped bentonite, as instructed by the CQA Officer and the RPR.

D The CQA Officer shall have the authority to request additional permeability tests in areas that, in the CQA Officer's judgment, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 3.01G. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. This sample will be held in a controlled environment at the CQA/CQA laboratories as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the compacted soil liner or that an error in testing occurred, the backup sample will be tested and the original test will be disregarded.

E If applicable, Grade stakes for liner construction shall be numbered by the Contractor and located on an inventory map. The inventory map shall be submitted to the CQA Officer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left in-place.

F The Contractor shall submit a survey plan with final elevation of top of compacted soil liner for CQA Officer's approval in accordance with Section 01050 prior to installing synthetic liner.

3.05 Corrective Action

A If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift shall be disced, moistened, and re-compacted. However, discing may produce large, hard clods of soil that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods of soil and hydration to take place uniformly. For this reason it will be necessary to remove the desiccated soil from the construction area, to process the lift in a separate processing area, and to replace the soil accordingly.

B Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

3.06 Reporting

A The Contractor's CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work associated with Compacted Soil Liner was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of South Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and documentation of re-worked areas with passing tests, as appropriate.

B Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02275

COMPACTED SOIL LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install compacted soil liner with a maximum in-place permeability of 1.0×10^{-7} cm/s of 24-inch minimum thickness as measured perpendicular to the slope as shown on the Drawings and as specified herein. Associated work includes quality control testing, borrow source excavation, hauling, screening, constructing a test pad, placement, moisture conditioning, harrowing, compaction, and grading of natural soil or soil-bentonite materials for bottom liner construction in the disposal unit.

1.02 RELATED WORK

A Section 01040: CQA Plan

B Section 01050: Field Engineering

C Section 02200: Excavation, Backfill, and Compaction

D Section 02776: Textured High Density Polyethylene (HDPE) Liner.

1.03 SUBMITTALS

A At least 45 days prior to test pad construction, the Contractor shall submit the following information in accordance with Section 01340:

1. Identification of the compacted soil liner type (natural soil or Contractor prepared soil-bentonite mix.)

2. If a natural soil is proposed, submit the following documentation:

   a. Name and location of the proposed natural soil borrow source,

   b. Test results and other documentation as necessary to verify that the proposed natural soil meets the requirements of 2.01A of this Section, and

   c. Anticipated volume of suitable natural soil available to the project.

3. If a soil-bentonite mixture is proposed, submit the following documentation:

a. Name and location of the proposed soil source,

b. Test results and other documentation as necessary to verify that the proposed soil meets the requirements of 2.01B of this Section,

c. Name and location of the bentonite supplier,

d. Test results and other documentation as necessary to verify that the proposed bentonite meets the requirements of 2.01C of this Section,

e. Anticipated bentonite application rate, and

f. Manufacturer's literature describing the pugmill to be used for preparing the soil-bentonite mix.

4. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

5. A description and schedule of the installation procedure and a list of installation equipment.

6. A Construction Quality Control (CQC) Plan for the compacted soil liner installation including:

a. Names and qualifications of the construction quality control firm and laboratory including the CQC Officer to be retained by the Contractor

b. Number, names and qualifications of CQC field personnel.

c. CQC procedures for borrow excavation and test pad construction.

d. CQC procedures for installation including exclusion and removal of oversized particles and organic matter from the compacted soil liner material, moisture control, placement, mixing, compaction and lift thickness control.

e. Site plan or map with 1-acre grid blocks to track and demonstrate field Quality Control testing described in Paragraph 3.04 of this Section.

f. Procedure for protection of liner from adverse weather conditions (precipitation, frost, or intense heat) and all other relevant procedures.

7. Experience and performance credentials, resumes, etc. in conformance with Paragraph 1.06A.

8. Samples from the material source to be used in the liner installation, to be collected by CQC.

9. Subgrade elevations in a form acceptable by the Engineer.

B. At least 21 calendar days prior to test pad construction, submit the results of testing conducted by CQC that demonstrates the proposed compacted soil liner material meets the requirements of Paraqraphs 2.01A and 2.01B.

C. At least 21 calendar days prior to test pad construction, submit at least 100 lbs of the proposed compacted soil liner material contained in sealed 5-gallon pails and at least a 10 sf. section of the approved textured high density polyethylene (HDPE) liner (Section 02776) to the Engineer.

1.04 REFERENCE STANDARDS

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer Than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2937 - Standard Test Method for Density of Soils in Place by the Drive-Cylinder Method.

10. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

13. ASTM D4767 - Test method for Consolidated - Undrained Triaxial Compression Test on Cohesive Soils.

14. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

15. ASTM D5321 - Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic friction by the Direct Shear Method.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A The Owner will retain a geotechnical CQA Officer who is experienced in the construction of compacted soil liners. The CQA Officer and his/her representatives shall observe the Contractors work and perform tests as specified to provide assurance that the liner meets the requirements of this specification.

B The Contractor will retain an independent geotechnical CQC Officer that is experienced in the construction of compacted soil liners and who is capable of performing the tests specified herein and who has sufficient hydraulic conductivity testing equipment to provide test results in a timely manner (5-7 days) in accordance with the Specification. The CQC Officer shall provide direction and testing as necessary to control the quality of the borrow material (material property requirements specified in Paragraphs 2.01A and B) mixing procedures and thoroughness, bentonite application rate, moisture control for the pugmill operation, and proper construction of the test pad and the compacted soil liner.

C An "acceptable zone" and testing shall be submitted as detailed in Section 2.02C by the CQC Officer.

D After the acceptable zone testing has been performed and approved by the CQA Officer, a test pad shall be constructed on site using the same equipment and installation procedures that will be used during full-scale liner construction.

The purpose of the test pad is to assure that the construction procedures proposed for full scale liner installation will produce an acceptable liner. Construction requirements and testing procedures for the test pad are specified in Paragraph 3.01.

1.06 QUALIFICATIONS

A The work shall be performed by personnel that have experience in processing and installation of a low permeability soil liners.

1.07 DELIVERY, STORAGE AND HANDLING

A Materials may be stockpiled on-site in designated approved areas. Each type of material shall be stockpiled separately. Removal and placement of material shall be done in a manner to minimize mixing with soils adjacent to and beneath the stockpile.

B If a soil-bentonite mixture is used, both the stockpiled soil to be used in the mix and the soil-bentonite mixture, if stockpiled, shall be sealed or covered with an impermeable cover at the end of each day and during rain events.

C The bentonite storage sites should be cleared and level. Bentonite material shall be contained and covered to preserve the fitness and quality of the material.

D The Contractor shall protect the natural soil or the soil-bentonite mixture materials delivered to the site from inclement weather conditions and any traffic that may occur near the stockpile.

PART 2: PRODUCT

2.01 MATERIALS

A Compacted soil liner materials, **whether natural soil or soil-bentonite mixtures**, shall conform to the properties listed in Table 1:

TABLE 1

PROPERTY	TEST METHOD	REQUIREMENT
Passing the 1.5-inch Sieve (%)	ASTM D422	100% minimum
Passing the 10 Sieve (%)	ASTM D422	90% minimum
Passing the 200 Sieve (%)	ASTM D1140	50% minimum
Liquid Limit	ASTM D4318	40% minimum
Plasticity Index	ASTM D4318	15% minimum
USCS Soil Classification	ASTM D2488	CH, CL, MH, ML, SC
Hydraulic Conductivity	ASTM D5084	$1.0x10^{-7}$ cm/s
Interface Effective Friction Angle (w/Textured HDPE)	ASTM D5321	24° minimum
Internal Effective Friction Angle	ASTM D4767	24° minimum
Organic Content	ASTM D2974	3% maximum

B If a soil-bentonite mixture is used for the compacted soil liner, the soil to be used for the mixture shall consist of a natural mineral soil that is free from fill materials, organic materials, loam, wood, trash, snow, ice and other objectionable materials and shall conform to the properties in Table 1:

C If a soil-bentonite mixture is used for the compacted soil liner, the bentonite used in the mixture shall be a free flowing, high swelling, sodium-based, Wyoming bentonite. The bentonite shall conform to all items of this specification. Certified test data shall be submitted to the Engineer for approval. The requirements are as follows:

1. The bentonite shall meet the contamination resistance criterion defined as the ability of the bentonite, when pre-hydrated with fresh water for a minimum of 72 hours, and tested at the rate of 2.5 lbs. per square foot mixed into a 2-inch layer of SP type sand to maintain hydraulic conductivity for a minimum of 200 days after introduction of a solution containing 3% ammonium chloride into the testing device, or equivalent certification that meets the approval of the Engineer.

2. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D The natural soil or soil-bentonite mixture material proposed for liner construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0×10^{-7} cm/s or less based on testing according Paragraph 3.01H.

E If a soil-bentonite mixture is used for the compacted soil liner, the soil-bentonite blending shall be accomplished using a pugmill and the Contractor shall demonstrate to the satisfaction of the Engineer that the proposed blending method will produce a consistent end product.

F. The Contractor shall show evidence of an adequate, homogenous supply of material within a designated area which is properly permitted by the appropriate local, State and Federal agencies.

2.02 CONFORMANCE TESTING

A Initial conformance testing shall be performed by CQC on samples from the natural soil source, or soil source for a soil-bentonite mixture, to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of CQC. The following tests shall be performed on the samples. For soil to be used in a soil-bentonite mix, tests 5, 8 and 9 are to be performed on the soil-bentonite mixture. Normal stresses representing field conditions should be used for the internal and interface shear tests. The effective and total shear strength friction angle should be reported.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) – *including hydrometer analysis*
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Relationship Curves (ASTM D698)
5. Laboratory Hydraulic Conductivity (ASTM D5084, except as modified in Paragraph 3.01H)
6. Natural Moisture (ASTM D2216)
7. Specific Gravity (ASTM D854)
8. Shear Tests for compacted soil liner material (ASTM D4767 or as approved by the Engineer)
9. Interface Shear Tests (soil/synthetic liner or soil-bentonite/synthetic liner) – *using a direct shear, rotational shear, or as approved by Engineer*

B If a soil-bentonite mixture is proposed for the compacted soil liner, the Contractor shall be responsible for establishing the percentage of bentonite to be used for the test pad construction based on the results of laboratory testing conducted by CQC specified in 2.02A, above, on the soil-bentonite mixture.

This testing shall be completed with the results furnished to the Engineer at least 21 calendar days prior to beginning test pad construction.

C For natural soil sources, the CQC Officer shall determine an acceptable zone of moisture contents and dry unit weights for which permeabilities are less than or equal to 1.0×10^{-7} cm/s by performing the following testing and analysis procedures:

1. Using the samples extracted from the proposed soil source, perform a Standard Proctor compaction test to develop a moisture-density curve for a representative sample of material. Use five specimens at incremental moisture contents to develop the compaction curve showing dry density for each molding water content.

2. Permeate compacted specimens, compaction to different moisture contents and densities, to determine their hydraulic conductivity. The compacted soil liner shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698

3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1.0×10^{-7} cm/s.

4. Draw an "acceptable zone" of water content and dry density around the passing samples.

5. Perform Internal Shear Tests (ASTM D4767) and Interface Shear Tests (ASTM D5321 and Paragraph 2.01E) on one specimen of the compacted soil liner material. The sample for each test should be remolded wet of the optimum moisture content and within the acceptable zone for the percent compaction and the moisture content that is anticipated for construction. The CQA Officer may require additional internal shear tests and interface shears tests if the compacted soil liner's proposed placement moisture content and percent compaction differs substantially from the shear test result's moisture content and percent compaction presented above. Additional shear strength tests will be at the cost of the Contractor.

   For Internal Shear Tests (ASTM D4767), use the following parameters:

   A. Strain rate/shear rate required: As recommended in ASTM D4767

   B. Consolidation pressures required: 1.5 psi, 5 psi, 40 psi

   C. Consolidation/seat time for samples: As recommended in ASTM D4767

For Interface Shear Tests (ASTM D5321), use the following parameters:

A. Strain rate/shear rate required: See ASTM D5321, Paragraph 8.2 and Paragraph 11.6. Due to varying soil types, if strain rate adjustments to the above referenced Paragraphs are required due to pore pressure dissipation problems, submit recommended adjustments for review by Engineer.

B. Normal stresses required: 1.5 psi, 5 psi, 40 psi

C. Consolidation/seat time for samples: As recommended in ASTM D5321, typically, 16-24 hours per normal stress application prior to initiating shear rate

6. Based on the shear test results and other pertinent factors such as constructability, shrink/swell potential, potential for desiccation cracks, and consolidation, the CQC Officer shall modify the acceptable zone as required.

7. CQC shall provide the graphs described above to the Contractor. If additional sources are used, the tests described above shall be performed by the CQC and the costs will be paid by the Contractor.

D For soil-bentonite mixes, once the Contractor has selected the bentonite application rate and completed the testing and submitted the test data and results as indicated in 2.02B, above, CQC shall perform the acceptable testing described in 2.02C above, prior to constructing the test pad.

E The natural soil or soil (for soil-bentonite mixture) source shall be tested by the CQC at the minimum frequencies specified in Table 2. If changes in material, as identified by the CQA Officer or CQC representative, occur within the frequency prescribed below, additional tests shall be performed at the expense of the Contractor.

TABLE 2

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	Every 2,500 cy
Atterberg Limits	ASTM D4318	Every 2,500 cy
Moisture/Density	ASTM D698	Every 5,000 cy
Natural Moisture	ASTM D2216	Every 2,500 cy

Results of the tests shall be submitted to the CQA Officer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 TEST PAD

A A test pad of a dimension of no less than 40-ft by 60-ft and 24-inch thickness shall be constructed on-site using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The compacted soil liner material to be used for the test pad shall be the same material that the Contractor proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the liner limits and incorporated in the work, provided the pad passes all testing requirements. Test pad soils tests shall be independent of and not be included in the full-scale soil liner testing results.

B The construction of the pad shall be directed by the CQC Engineer. The CQC Engineer shall use the acceptable zone established to set moisture contents and percent compaction. CQC shall perform tests as needed to assist in the construction of the test pad. Both the CQC and CQA field and laboratory testing will be evaluated for determining the performance of the test pad

C The compacted soil liner in the test pad shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

D The final compacted thickness of each lift shall be a maximum 6" lift thickness. For each lift, the CQC shall perform testing of moisture content and density at a minimum of three test locations. Two thin-wall tube samples shall be obtained per lift by the CQC. One tube will be used to perform a permeability test. The second tube will be kept as a backup in case of damage to the first sample.

E If the initial test pad does not provide the specified results, additional test pad(s) shall be performed, at the Contractor's cost (including CQA costs), until the specified requirements are met.

F For compacted soil liner consisting of a soil-bentonite mix, the bentonite content used for the test pad shall be set by the Contractor and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

G The Contractor may construct test pads for more than one source of compacted soil liner material or soil-bentonite mix ratios. However, only one test pad will be tested and evaluated at the Owner's cost as a part of the specified construction quality assurance (CQA). All costs associated with subsequent test pads shall be paid for by the Contractor. If the Contractor changes the source of natural soil or soil (for the soil-bentonite mixture) or if

the characteristics of the natural soil or the soil within the selected source changes significantly, the Engineer may order the construction of additional test pads and subsequent tests as specified above as may be necessary to evaluate the performance of the compacted soil or soil-bentonite liner. Construction of additional test pads and the related CQA work shall be paid for by the contractor.

H One triaxial hydraulic conductivity test (ASTM D5084) will be performed on each lift of the test pad. These tests will be performed on undisturbed thin-wall tube samples collected by CQC in accordance with ASTM D1587. The samples shall be trimmed if needed, encapsulated within a flexible latex membrane, and mounted in permeameters conforming to the requirements of ASTM D5084. Each test specimen shall be consolidated under an effective stress of 8 to 12 psi and permeated under a backpressure as recommended in paragraph 8.3 of ASTM D5084 to achieve saturation. The maximum hydraulic gradient across the sample shall not exceed thirty (30) as per paragraph 8.5.1 of ASTM D5084 or as specified by Engineer. The hydraulic gradient shall be increased slowly in increments with careful observations of the test sample for consolidation, piping, etc. Test samples that are consolidated in volume by more than 5 percent during the test shall be voided. The inflow and outflow from the sample shall then be monitored and the hydraulic conductivity calculated for each recorded flow increment. The tests will continue until steady state flow is achieved as specified in paragraph 8.5 of ASTM D5084.

I The compacted soil liner thickness shall be determined from three test locations per lift selected by CQC per test pad using a method consisting of hand augering or push tube sampling (with a minimum of a 3/4" diameter sample) or as approved by the Engineer. Holes in the compacted soil liner shall be backfilled by the Contractor with dry powdered or chipped bentonite.

3.02 SUBGRADE PREPARATION

A The subgrade shall be graded to elevations in accordance with the plans.

B The compacted soil liner subgrade shall be proofrolled by the Contractor in accordance with Section 02200 and examined by the CQA Officer and/or the RPR to detect unstable or loose soils. Based on observation during the proofrolling operation, the CQA Officer and the RPR reserves the right to select the number and direction of passes to be used. Any unsuitable soils encountered at subgrade elevation shall be removed and replaced as directed by the CQA Officer and/or the RPR at no additional cost to the Owner.

C The subgrade surface shall not be smooth rolled. The subgrade surface shall be left in a roughened condition to allow good adherence between the subgrade and the initial lift of the compacted soil liner.

D The CQA Officer shall observe and approve the subgrade and the survey plan of subgrade elevation submitted by the Contractor before installation of the compacted soil liner can proceed. It shall be the Contractor's responsibility to properly prepare and maintain the subgrade in a uniform and compacted condition during installation of the liner.

E If the subgrade is damaged during liner installation, the Contractor shall restore and re-compact the area; CQC shall re-test the subgrade in accordance with ASTM D1556, D2922, or D2937 prior to installing the liner. All costs related to the re-test and restoration of the subgrade shall be paid for by the Contractor.

3.03 SOIL OR SOIL-BENTONITE LINER PLACEMENT

A The CQC Officer and his/her site representatives shall supervise the liner installation. Work shall not be performed by the Contractor without the CQA Officer and/or the RPR onsite. CQA and CQC shall perform field tests (i.e. moisture content, densities, etc.) as required to ensure proper installation. CQA and CQC shall perform tests as described in section 3.04 to determine acceptance of the in-place liner.

B. The compacted soil liner material shall be compacted to a dry density equal to or greater than 95 percent of its maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

C The placement moisture content shall be within the acceptable zone of moisture content as determined by the CQC Officer during the conformance testing of the natural soil or soil-bentonite mixture described in paragraph 2.02C. The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

D Water for Construction of the Soil Liner

1. The Contractor shall provide water as required to achieve the required moisture content, unless otherwise specified in the Contract Documents.

2. The water shall be from an approved source.

3. Prior to installing the liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the compacted soil liner material be stockpiled for any length of time, the Contractor shall slope, seal and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper percentage.

E The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content or 95 percent of its maximum dry density, whichever is greater. The acceptable zone shall be as specified by the CQC Officer in accordance with the procedures outlined in 2.02C. Density shall be uniformly obtained throughout the entire thickness of the liner. The compacted soil liner shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift. The surface of a lower lift shall be scarified, if needed, prior to placement of an upper lift. During placement of the initial lift care should be taken to avoid mixing of the liner material and subgrade material.

F To achieve the specified compaction the Contractor shall use a self-propelled compactor equipped with steel kneading feet capable of fully penetrating the loose lift and into the previously compacted lift. A smooth wheel compactor shall be used with sufficient number of passes to smooth the upper surface of the compacted soil liner. A smooth wheel compactor shall be used only for final smoothing of the surface and not be used for achieving the specified compaction.

G Liner material shall be disced, harrowed, and kneaded as necessary to break down all clods and produce a uniform material that is free of clods. A clod is defined for the purposes of construction as any subrounded ball of soil exceeding 1/2" in diameter, typically with the core containing less than the specified moisture. If the CQA Officer and/or the RPR observe that all clods have not been broken down, the Contractor shall rework the material to the satisfaction of the CQA Officer and/or the RPR.

H Liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated soil materials.

I In the case of soil-bentonite mix for the compacted soil liner, the Contractor shall use a pugmill to blend the soil-bentonite mix at the required moisture content. Soil borrow material to be used for soil-bentonite compacted soil liner construction shall be shredded and screened by power methods to provide a uniform soil free of roots, stumps, and other organic materials, rocks, and debris and to provide particle sizes to be used in the compacted soil liner less than 1.5 inches in its longest dimension for natural soil and 1.5 inches in its longest dimension for soil-bentonite mixes.

J For the final lift, the contractor shall employ a crew of laborers to remove all rocks 1-inch or larger prior to smooth rolling.

K No liner material shall be placed, spread, or compacted while the ground or the liner material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The liner surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the liner material. Any re-grading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift or HDPE liner. Thickness measurements should be performed as indicated in Section 3.04 A. Areas previously meeting the conformance test requirements that are reworked in excess of the top 3-inch per lift shall be retested. Retesting will be at the cost of the Contractor.

L Should desiccation cracks develop, the liner shall be scarified, disced, rewetted, re-homogenized and re-compacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer and/or the RPR. If desiccation extends below half of the lift thickness, the entire lift shall be reworked and retested as described above. Retesting will be at the expense of the Contractor.

M During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the liner system and for moisture control and protection of the compacted soil liner.

N After finish grading and smooth rolling is completed, the compacted soil liner shall not be less than 24-inches in any location. Liner thickness will be tested by CQA and CQC personnel on a per lift basis at a frequency specified in 3.04A using a method of hand augering or push tube sampling (minimum 3/4" sample). This testing is primarily to estimate liner lift thickness and shall not be used to verify total dry liner thickness. The final compacted soil liner thickness will be determined from the Contractor's survey. Areas not meeting the thickness requirements shall be augmented with additional soil material. The Contractor's surveyor shall be available to assist in determining the areal extent of compacted soil liner that is not at least 24-inches thick. Any additional testing or CQA services associated with corrective action for achieving the 24-inch liner thickness requirement will be at the cost of the Contractor. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 3-inches of the liner shall be wetted, kneaded, compacted and re-worked with the additional material to obtain the required thickness.

3.04 QUALITY ASSURANCE DURING PLACEMENT

A The CQC/CQA personnel shall conduct tests during installation of the compacted soil liner at the minimum frequencies specified in Table 3. The

CQC Officer will provide direction and testing as necessary to the Contractor to control quality of the compacted soil liner materials to meet the specifications listed in Section 2.01; however, the results of CQC and CQA testing will both be considered in accepting or rejecting compacted soil liner materials.

TABLE 3

TEST	METHOD	FREQUENCY	
		CQC	CQA
Grain Size w/Hydrometer	ASTM D422	1/acre/lift	1/acre
Atterberg Limits	ASTM D4318	1/acre/lift	1/acre
Undisturbed Permeability	ASTM D5084	1/acre/lift	1/two acres
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	4/acre/lift	2/acre
Natural Moisture[1]	ASTM D2216 ASTM D3017 ASTM D1556	4/acre/lift (at density location)	2/acre
Liner thickness	Hand Auger or push tube	4/acre/lift	N/A

B The minimum testing frequencies for field tests to be performed by the Contractor's Quality Control personnel and the Owner's Quality Assurance personnel are identified in Sections 3.04. A. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the

density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

C All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the Contractor and/or CQC Officer with dry powdered or chipped bentonite, as instructed by the CQA Officer and the RPR.

D The CQA Officer shall have the authority to request additional permeability tests in areas that, in the CQA Officer's judgment, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 3.01G. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. This sample will be held in a controlled environment at the CQA/CQA laboratories as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the compacted soil liner or that an error in testing occurred, the backup sample will be tested and the original test will be disregarded.

E If applicable, Grade stakes for liner construction shall be numbered by the Contractor and located on an inventory map. The inventory map shall be submitted to the CQA Officer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left in-place.

F The Contractor shall submit a survey plan with final elevation of top of compacted soil liner for CQA Officer's approval in accordance with Section 01050 prior to installing synthetic liner.

3.05 Corrective Action

A If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift shall be disced, moistened, and re-compacted. However, discing may produce large, hard clods of soil that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods of soil and hydration to take place uniformly. For this reason it will be necessary to remove the desiccated soil from the construction area, to process the lift in a separate processing area, and to replace the soil accordingly.

B Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

3.06 Reporting

A The Contractor's CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work

associated with Compacted Soil Liner was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of South Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and documentation of re-worked areas with passing tests, as appropriate.

B Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02276

EROSION AND SEDIMENTATION CONTROL

PART 1: GENERAL

1.01 SCOPE OF WORK

A The work specified in this Section consists of providing, and maintaining erosion and sedimentation controls as necessary during construction. The CONTRACTOR is responsible for providing effective erosion and sediment control measures throughout construction.

B Erosion controls include, but are not limited to, surface stabilization which shall be accomplished with vegetation and mulch, erosion control matting, earthen diversion berms and ditches, and minimization of disturbed acreage. CONTRACTOR is responsible for preventing excessive on-site erosion during construction.

C Sedimentation controls include, but are not limited to, silt fences, sediment traps, temporary earthen diversion berms and ditches, check dams and appurtenances at the foot of sloped surface. Sedimentation pollution shall be prevented from off-site migration.

D CONTRACTOR shall be responsible for maintaining all existing erosion control structures in their existing conditions as they exist on the date of the Notice to Proceed for the duration of the PROJECT. This work includes, but is not limited to, all existing sedimentation ponds, rock check dams, and diversion ditches and berms. Maintenance shall include but not be limited to making all repairs necessary to maintain the structures as well as remove all accumulated sediment as necessary to maintain the structures in proper working condition.

E CONTRACTOR shall be responsible for maintaining all new erosion control structures including but not limited to, all sedimentation ponds, diversion ditches, rock check dams, and silt fence. Maintenance shall include but not be limited to making all repairs necessary to maintain the structures as well as remove all accumulated sediment as necessary to maintain the structures in proper working condition. The frequency of sediment removal from all on-site erosion control structures shall be bi-weekly at a minimum. All erosion control measures shall be inspected following each rainfall event. CONTRACTOR shall be responsible for constructing whatever diversion structures are necessary to ensure that all disturbed on-site drainage/run-off (within the limits described above) is routed through one of the existing on-site rock check dams, sediment traps, or sediment ponds. Silt fence shall be installed as needed to insure against off-site runoff until all diversion structures are constructed and operational.

F Any stockpiles established shall be protected from erosion by providing silt fences along the toe of the slopes, seeding the side slopes and by maintaining stable slopes.

1.02 REFERENCE DOCUMENTS

A South Carolina Stormwater Management and Sediment Control Handbook

B EPA Storm Water Management for Industrial Activities

PART 2: PRODUCTS

2.01 EROSION AND SEDIMENT CONTROL

A Stabilization by seeding and mulching

B Erosion Control Mattings

C Rip-rap and washed stone

D Silt fence

E Temporary earthen diversion berm and ditches

F Sediment Traps, check dams and energy dissipaters

G Sediment Ponds

PART 3: EXECUTION

3.01 EROSION CONTROL

A Maintain all existing erosion and sediment control structures and appurtenances as detailed on the plans.

B Install and maintain new erosion and sediment control structures and appurtenances as detailed on the plans.

C Install and maintain temporary erosion and sediment control structures and appurtenances as necessary to prevent erosion from CONTRACTOR'S work.

3.02 PERFORMANCE

A CONTRACTOR shall immediately take whatever steps are necessary to maintain any existing erosion and sediment control structures and appurtenances in the condition as they existed on the date of the Notice to Proceed.

B CONTRACTOR shall construct all new erosion and sediment control structures and appurtenances as detailed on the plans in a manner that minimizes erosion from areas of the CONTRACTOR'S work.

C Should any temporary erosion and sediment control measures employed by the CONTRACTOR fail to produce results which comply with the State and local enforcement requirements, CONTRACTOR shall immediately take whatever steps are necessary to correct the deficiency at his own expense.

D CONTRACTOR shall inspect all erosion and sediment control devices for each period of precipitation to ensure proper operation. Any erosion and sediment control devices found not to be properly functioning, shall be immediately corrected.

END OF SECTION

SECTION 02277

GEOSYNTHETIC CLAY LINER (GCL)

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install bentonite contained reinforced geosynthetic clay liner (GCL) as shown on the Drawings and as specified herein. Associated work includes sample collection, testing, loading, delivery, storage and handling and placement. All work shall be in accordance with the procedures provided herein and in the contract drawings.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill and Compaction

B Section 02275: Compacted Soil Liner

C Section 02776: HDPE Liner

1.03 SUBMITTALS

A 45 days prior to the materials scheduled installation, submit the following information in accordance with Section 01340:

1. Identification of the GCL manufacturer.

2. Documentation that the GCL manufacturer and installer meet the requirements of Paragraph 2.01 of this Section.

2. A signed certification from the manufacturer stating that materials are first quality products designed and manufactured specifically for the purposes of this work and which has been satisfactorily demonstrated by prior use to be suitable and durable for such use.

3. A description of the installation procedures and a schedule to include GCL installation and a list of installation equipment.

4. A Quality Control Plan for the GCL manufactured product and installation.

5. Three samples of the GCL material to be used for laboratory testing.

1.04 REFERENCE STANDARDS

A American Society for Testing Materials (ASTM)

1. ASTM D5890 - Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.

2. ASTM D5891 - Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.

3. ASTM D5993 - Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners.

4. ASTM D6768 - Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

5. ASTM D6496 - Standard Test Method for Determining Average Bonding Peel Strength between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.

6. ASTM D5887 - Standard Test Method for Measurement of Index Flux through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

7. ASTM D6243 - Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

B GRI-GCL3 – test methods, required properties and testing frequencies of Geosynthetic Clay Liners (GCL's)

C Where reference is made to one of the above standards, the revision in effect at the time of bid opening will apply.

1.05 QUALITY ASSURANCE

A Quality control and quality assurance consists of laboratory conformance testing of samples supplied from the manufacturer and observation and quality control during installation.

B The CONTRACTOR will retain an independent geotechnical Quality Assurance Laboratory (QAL) who has specific permeability equipment to provide test results in a timely manner in accordance with the Specifications. The CONTRACTOR shall coordinate and schedule all tests as required by the Drawings and Specifications.

C Conformance testing requirements are specified in Paragraph 2.01. The purpose of conformance testing is to assure that the supplied material conforms to the

Specifications and specified permeability.

D Field quality control requirements are specified in Paragraph 3.04. The purpose of field quality control procedures is to assure that the GCL has been installed in accordance with the specifications and achieved the specified hydraulic conductivity.

1.06 QUALIFICATIONS

A Material shall be supplied and the work shall be performed by a firm that has experience in processing and installation of GCL.

B Manufacturer

1. The manufacturer of the GCL shall have a minimum of 3 years of continuous experience in the manufacture of similar GCL products.

2. The manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 2 million square feet of manufacturing experience of similar GCL products.

3. The manufacturer shall submit a list of not less than 10 previous jobs. The list shall include the following for each project:

    - Name of Project/Date Installed
    - Brief Description of Project
    - Quantity of GCL
    - Owner's Name, Address, Contact and Phone
    - CQA Officer's Name, Address, Contact and Phone
    - Installer's Name, Address, Contact and Phone

C Installer

1. The installer must demonstrate previous GCL experience for projects totaling at least 1 million square feet. In lieu of this requirement, the installer can provide written certification from the manufacturer stating that the installer is adequately trained in the installation of GCL's. A project reference list and the same information as listed in Paragraph 1.06.B.3 shall be submitted.

1.07 DELIVERY, STORAGE AND HANDLING

A Delivery, Storage and Handling of GCL shall be the responsibility of the Contractor. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well drained.

B The GCL shall be shipped, stored, and handled in accordance with the

manufacturer's recommendations , but at a minimum shall be protected from UV exposure and elevated from the ground a minimum of three inches. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

1.08 MATERIAL WARRANTY

A The GCL Manufacturer shall warrant the material against manufacturing defects for a period of at least five years from the date of installation. The manufacturer shall replace any material that fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the GCL against defects in installation and workmanship for a period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A. The GCL shall consist of a layer of granular sodium bentonite clay needle punched between two geotextiles and shall comply with all of the criteria listed in this Section.

B. Bentonite shall be a high-swelling sodium bentonite, with a minimum swell index of 24 mL/2g and a maximum fluid loss of 18 mL. Bentonite shall be CG-50 granular bentonite, mined and processed by American Colloid Company.

C. Bentonite shall have a granular consistency (1 percent max. passing a No. 200 sieve [75 μm]), to ensure uniform distribution throughout the GCL and minimal edge loss during handling and installation.

D. Acceptable GCL products are Bentomat ST as manufactured by CETCO, Arlington Heights, IL, or approved equal.

E. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. Contractor must also provide evidence of successful use of the proposed alternate material on past similar projects. This evidence can include past direct shear results against similar materials under similar site conditions, and/or past permeability/compatibility test results with a similar leachate or waste stream. The CQA Officer must approve any alternate

GCL materials.

F. Reinforced GCL shall be used for the entire project.

G. No desiccation of GCL components from the bentonite core shall occur.

H. Acceptable GCL products are Bentomat ST as manufactured by CETCO, Arlington Heights, IL, or approved equal.

I. GCL panels shall be a minimum of 4 feet wide.

J. The GCL shall be wound around a rigid core sufficient to facilitate handling. All rolls shall be labeled and bagged in packaging that is resistant to photo-degradation by ultraviolet (UV) light.

K. The GCL shall comply with the following properties as listed in Table 1.

TABLE 1

MATERIAL PROPERTY	TEST METHOD	REQUIRED VALUES (1)
Bentonite Swell Index	ASTM D5890	24 mL/2g min.
Bentonite Fluid Loss	ASTM D5891	18 mL max.
Bentonite Mass/Area(2)	ASTM D5993	0.75 lb/sf min.
GCL Tensile Strength (3)	ASTM D6768	30 lbs/in. MARV
GCL Peel Strength	ASTM D6496	3.5 lbs/in min.
GCL Hydraulic Conductivity (4)	ASTM D5887	5×10^{-9} cm/sec max.
GCL Internal Hydrated Sheer Strength(5)	ASTM D5321	500psf

Notes:

(1) All values are minimum average roll values unless otherwise noted.
(2) Reported at 0-percent moisture content
(3) Performed in the machine direction
(4) De-aired, distilled tap water @ 80psi cell pressure, 77psi headwater pressure, 75 tailwater pressure
(5) Measured at 200psf normal stress; hydrated at 48-hours.

2.02 MANUFACTURERS QUALITY CONTROL DOCUMENTATION

A Prior to installation of any GCL, the Contractor shall provide to the CQA Officer, the following information certified by the manufacturer for the proposed GCL:

1. Each roll delivered to the Project site shall have the following identification information:
   a. Manufacturer's name
   b. Product information
   c. Roll dimensions
   d. Lot and roll number
2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At minimum, the following test results shall be provided in accordance with the requirements specified in Section 2.01.
   a. Bentonite free swell and fluid loss (1 test every 50 tonnes, which corresponds to about 1 test every 130,000 square feet)
   b. Bentonite Fluid Loss (1 test every 50 tonnes)
   c. Bentonite mass/area (1 test every 40,000 square feet)
   d. GCL tensile strength (1 test every 200,000 square feet)
   e. GCL peel strength (1 test every 40,000 square feet)
   f. GCL permeability (1 test per lot)
   g. GCL hydrated internal shear strength (per manufacturer's standard test frequency)

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by an approved Independent Quality Assurance Laboratory (QAL) approved by the Owner and CQA Officer. The Laboratory (prior to shipping) or RPR (upon delivery) shall obtain samples from the proposed material, mark the machine direction, lot number and roll identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the CQA Officer. The Contractor shall pay for the initial test for every change in Lot number. The samples shall be taken across the entire roll width and shall not include the first three feet. The following conformance tests shall be conducted on the GCL samples at the QAL.

1. Bentonite mass per unit area (ASTM D5993)
2. Bentonite Swell Index (ASTM D5890)
3. GCL Grab Strength (ASTM D6768)
4. GCL Peel Strength (ASTM D6496)

B All conformance test results shall be reviewed by the CQA Officer and accepted, prior to the deployment of the GCL. All test results shall meet, or exceed, the

property values listed in Section 2.01. The course of action implemented for retesting a failed test shall be approved by the CQA OFFICER.

PART 3: EXECUTION

3.01 SUBGRADE PREPARATION

A Preparation of the subgrade shall be as specified Sections 02275.

B The CONTRACTOR and the CQA Officer or RPR shall inspect and approve the subgrade before installation of the GCL can proceed. The CONTRACTOR is responsible for properly preparing and maintaining the subgrade free of water and in a smooth, clean, uniform, and compacted condition during installation of the GCL.

3.02 GCL PLACEMENT

A Panel Placement

1. At minimum, the Manufacturer's recommended installation procedures shall be followed.

2. GCL rolls shall be brought to the area to be lined in their original packaging. Immediately prior to deployment, the packaging should be carefully removed. Unless otherwise specified, the GCL shall be installed such that the side of the GCL with the lamination on it faces up.

3. Rolls shall be handled utilizing a solid steel bar inserted through the core and slings or chains attached to the ends of a spreader bar. The core bare shall be suspended from the spreader bar so that the edges of the liner are not damaged by the suspending straps or chains.

4. Dragging of the GCL panels over the surface shall be minimized. A slip or rub sheet shall be used to minimize friction during placement. In addition, during installation of the HDPE liner over the GCL, a slip or rub sheet shall also be used to allow the HDPE liner to move more freely into place.

5. The GCL will be placed over the prepared surface in such a manner as to assure minimum handling.

6. The GCL panels shall be placed parallel to the direction of the slope.

7. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.

8. The GCL shall not be wet prior to installation or installed in standing water or

during rain. The GCL must be dry when installed, dry when covered and not get wet while exposed. Only as much GCL shall be deployed as can be covered at the end of the working day with soil or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material.

9. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Bentonite-enhanced seams are required.

10. The minimum dimension of the longitudinal overlap should be 6 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches.

11. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

12. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap.

13. The granular bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m). The granular bentonite sealing clay used for overlap seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer. Seaming of GCLs shall be conducted in accordance with the manufacturer's specifications for each particular GCL.

14. Only as much GCL shall be deployed as can be covered at the end of the working day with a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight.

B Cover Placement

1. Cover soils shall be free of angular stones or other foreign matter that could damage the GCL.

2. Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 1 foot of cover should be maintained between the equipment tires/tracks and the GCL at all

times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 2 feet is required.

3. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones. Cover soil shall be pushed up slopes, not down slopes, to minimize tensile forces on the GCL.

4. Cyclical wetting and drying of GCL covered with geomembrane can cause overlap separation. Soil cover should be placed promptly to avoid this problem. Geomembranes should be covered with a white geotextile and/or operations layer without delay to prevent the geomembrane from absorbing heat and desiccating the bentonite in the GCL. If the GCL is covered only with a geomembrane for an extended period, the overlapping of the longitudinal seams needs to be increased to 12".

3.04 FIELD QUALITY CONTROL

A Construction Inspection Procedures

1. The field quality control (QC) documentation shall be reviewed by the CQA Officer to ensure the finished GCL meets or exceeds all of the criteria listed in Table 1 with the testing frequency listed.

2. All delivered GCL rolls shall be visually inspected and approved by the CQA Officer prior to installation. Defects or damage from shipping and handling shall be grounds for rejection at the discretion of the CQA Officer.

3. Each day, the Contractor's and/or installer's superintendent and the CQA Officer should inspect and provide written certification that the subgrade for the GCL has been prepared in accordance with the specifications.

4. As each GCL panel is being deployed, the Contractor and/or installer's superintendent and CQA Representative shall provide inspection of the installation. This shall include:

   a. Inspection of overlap

   b. Visual inspection of geotextile quality, bentonite uniformity, and the degree of hydration, if any, on the GCL; marking of any areas as appropriate for repair.

   c. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches is

achieved around all of the damaged area. Granular bentonite or bentonite mastic should be applied around the damaged area prior to placement of the patch. An adhesive shall be used to affix the patch in place so that it is not displaced during cover placement

END OF SECTION

SECTION 02280

INFILTRATION LAYER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install Infiltration Layer of 18-inch minimum thickness as shown on the Drawings and as specified herein. Associated work includes borrow source excavation, hauling, placement, moisture conditioning, processing, compaction, quality control testing and grading of low permeability soil for Infiltration Layer construction.

1.02 RELATED WORK

A Section 01050: Field Engineering

B Section 01410: CQA Plan

C Section 02200: Excavation, Backfill, and Compaction

D Section 02701: Drainage and Erosion Layer

1.03 SUBMITTALS

A Within 30 calendar days prior to furnishing and installing the Infiltration Layer, the CONTRACTOR shall submit the following in accordance with Section 01340:

1. Identification of the low permeability soil source. Bentonite augmentation of soils to achieve the permeability requirement is allowed. If a soil bentonite mix is to be used, the bentonite supplier must also be identified at this time.

2. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

3. A description and schedule of the installation procedure and a list of installation equipment.

4. Experience and performance questionnaire in conformance with Paragraph 1.06A.

5. Samples from the material source (75 pounds each) to be used in the liner installation, to be supplied by the CONTRACTOR to the ENGINEER.

6. Subgrade elevations in a form acceptable to the ENGINEER.

7. A Quality Control Field Testing Plan for review by the ENGINEER. It should identify the required frequencies set forth in 3.04.A of this Section and include a map of the closure area with 1-acre grid blocks and the CONTRACTOR'S planned sequence of work.

1.04 REFERENCE STANDARDS

A ASTM - American Society for Testing and Materials:

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer Than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6. ASTM D1557 - Standard Test Methods for Moisture-Density Relations of Soils Aggregate Mixtures Using 10-lb (4.54 kg) Hammer and 18-in (457 mm) Drop.

7. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

8. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

9. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

10. ASTM D2937 - Standard Test Method for Density of Soils in Place by the Drive-Cylinder Method.

11. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

12. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

13. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

14. ASTM D4767 - Test method for Consolidated - Undrained Triaxial Compression Test on Cohesive Soils.

15. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

16. ASTM D2166 - Unconfined Compressive Strength

17. ASTM D2573 - Field Vane Shear Test

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A The OWNER will retain an independent Construction Quality Assurance (CQA) Firm that is experienced in the construction of low permeable compacted clay liners and capable of performing the tests specified herein. The OWNER's CQA Firm shall be responsible for observing, testing and documenting activities related to the CQA of the construction at the site. The CQA Firm will be represented on site by the Resident Project Engineer (RPR). The CQA Firm shall be responsible for preparing the final certification report. The CQA Firm shall have the option to perform the testing or subcontract the testing to an independent geotechnical testing laboratory who is experienced in the construction of infiltration liners and who has sufficient hydraulic conductivity testing equipment to provide test results in a timely manner in accordance with the Specifications.

B The CONTRACTOR will retain an independent Construction Quality Control (CQC) Firm that is experienced in the construction of low permeable compacted clay liners and capable of performing the tests specified herein. The CONTRACTOR'S CQC Firm shall have a CQC Officer who is responsible for all work performed by the CONTRACTOR'S CQC Firm and is a licensed Professional Engineer in South Carolina. The CONTRACTOR'S CQC Firm shall provide direction as necessary, to the CONTRACTOR to control the quality of the borrow material, test pad, and

the installed liner. All costs associated with tests performed by the CONTRACTOR'S CQC Firm will be borne by the CONTRACTOR.

C Conformance testing requirements are specified in Paragraph 2.02. The purpose of conformance testing is to assure that the liner material delivered from the borrow source consistently meets the requirements of the specifications. In the case that the initial borrow source samples fail to conform to the required criteria, the CONTRACTOR may locate another source, and upon approval of that source by the OWNER, submit samples from the new source for conformance testing. The CONTRACTOR will be responsible for the costs of any testing required for more than one borrow source.

D A test pad shall be constructed on site using the same equipment and installation procedures that will be used during full-scale liner construction. The purpose of the test pad is to assure that the construction procedures followed during liner installation will produce an Infiltration Layer that meets the PROJECT requirements. Construction requirements and testing procedures for the test pad are specified in Paragraph 3.01.

E Material to be used for Infiltration Layer construction (either natural soil or bentonite augmented soil) must be uniform soil free of roots, stumps, and other organic materials, rocks, and debris and meets the specification requirements listed in Paragraph 2.01. The CQA Officer can require the use of power methods to shred or screen the material if the CONTRACTOR cannot provide uniformity of material as described above.

1.06 QUALIFICATIONS

A The work shall be performed by personnel that have experience in landfill closure construction and processing and installation of a final cover Infiltration Layer.

B The CONTRACTOR shall show evidence of an adequate, uniform supply of material within a designated area which is properly permitted by the appropriate local, State and Federal agencies. (See item 2.02,A of this section)

1.07 DELIVERY, STORAGE AND HANDLING

A Materials shall be stockpiled on-site in designated areas approved by the OWNER. Each type of material shall be stockpiled separately. Removal and placement of material shall be done in a manner to prevent mixing with soils adjacent to and beneath the stockpile.

B Stockpiled soil to be used in the construction of the Infiltration Layer will be sealed or covered with an impermeable cover at the end of each day and during rain events.

C The CONTRACTOR shall protect the soil stockpile for the Infiltration Layer delivered to the site from inclement weather conditions and any traffic that may occur near the stockpile. Vegetation, debris, or other deleterious materials that occur or deposit on the stockpile must be removed prior to its intended use.

PART 2: PRODUCT

2.01 MATERIALS

A Soil for the Infiltration Layer shall conform to the properties specified in Table 1.

TABLE 1

Test	Test Method	Required Property
Passing the No. 4 Sieve	ASTM D422	80% min. with no single particle over 3 inches in its longest dimension
Passing the No. 200 Sieve	ASTM D1140	35% minimum
Soil Classification	ASTM D2487	CH,CL, MH, ML, SC, SM
Hydraulic Conductivity	ASTM D5084	1.0×10^{-5} cm/s max.
Internal Friction Angle	ASTM D4767	24° minimum, or as approved by the ENGINEER
Interface Friction Angle (with textured LLDPE, same LLDPE material proposed for the project	ASTM D5321	27° minimum, or as approved by the ENGINEER
Organic Content	ASTM D2974	3% maximum

B A soil-bentonite mixture may be used for the Infiltration Layer provided it achieves the specified hydraulic conductivity and interface and internal friction angles. Soil to be used for the soil-bentonite mix shall conform to the properties noted in 2.01A, items 1, 2, 5 and 8. The soil-bentonite mixture must conform to all items listed in 2.01A.

C If a soil-bentonite mixture is used, the bentonite shall be a free flowing, high swelling, sodium-based, Wyoming bentonite or other approved bentonite source. The bentonite shall conform to all items of this specification. Certified test data shall be submitted to the ENGINEER for approval. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D The natural soil or soil-bentonite mixture material used for cap construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0×10^{-5} cm/s or less (according to ASTM D5084).

E If the CONTRACTOR plans to blend soils to form Infiltration Layer material or soil for soil-bentonite mix, the CONTRACTOR shall demonstrate to the satisfaction of the ENGINEER that the proposed blending method will produce a consistent end product.

2.02 CONFORMANCE TESTING

A Initial conformance testing shall be performed by the CONTRACTOR's CQC Firm on samples from the natural soil source, or soil source for a soil-bentonite mixture, to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be excavated by the CONTRACTOR under the direction of the CONTRACTOR'S CQC Firm. Each of the following tests shall be performed on three representative samples or additional test sets per change in material. The results of the test methods anticipated for excavating and preparing the soils for use in the cap construction shall be compiled and discussed in a report by the CONTRACTOR'S CQC Firm and signed and sealed by the CONTRACTOR'S CQC Officer. The report should also estimate volume of material available for use as Infiltration Layer.

1. Soil Classification (ASTM D2487)

2. Particle Size Analysis (ASTM D422) - including hydrometer analysis

3. Atterberg Limits (ASTM 4318)

4. Moisture-Density Curves (ASTM D698)

5. Laboratory Hydraulic conductivity (ASTM D5084 except as modified in Paragraph 3.01-G)

6. Natural Moisture (ASTM D2216)

7. Triaxial Shear Tests for Infiltration Layer material (ASTM D4767 or as approved by the CQA ENGINEER)

8. Interface Shear Tests (clay/synthetic liner or soil-bentonite/synthetic liner) using a direct shear, rotational shear, or as approved by Engineer.

B For Infiltration Layer soil sources, the CONTRACTOR'S CQC Firm shall determine an acceptable zone of moisture contents and dry unit weights for which permeabilities are less than or equal to 1.0×10^{-5} cm/s by performing the following testing and analysis procedures. However, the placement moisture content for the soil liner shall in no case be dry of the optimum moisture content as determined by the standard Proctor method.

1. For each soil type proposed for the Infiltration Layer soil source, perform one standard Proctor compaction test.

2. Re-mold 4 specimens of the soil type from the compaction test in item B above at 0%, 1.5%, 3% and 5% wet of the optimum moisture content per ASTM D698. Permeate each compacted specimen to determine its hydraulic conductivity.

3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1.0×10^{-5} cm/s.

4. Draw an "acceptable zone" of water content and dry density around the passing samples.

5. Perform Internal Shear Tests (ASTM D4767) and Interface Shear Tests (ASTM D5321 and Paragraph 2.01E) on one specimen from each of the high and low ends of the acceptable zone and plot the friction angles (internal and interface with the textured synthetic liner) as a function of molding water content

6. Based on pertinent factors such as constructability, shrink/swell potential, potential for desiccation cracks, and consolidation, the CONTRACTOR'S CQC Firm shall modify the acceptable zone as required.

7. The CONTRACTOR'S CQC Firm shall provide the results of the tests described above to the Engineer for one material source in a letter signed and sealed by the CONTRACTOR'S CQC Officer. If additional sources are used, the tests described above shall be performed by the CONTRACTOR'S CQC Firm and the costs will be paid by the CONTRACTOR.

C For soil-bentonite mixes, the CONTRACTOR shall be responsible for performing preliminary permeability tests on initial mix ratios (based on manufacturer's recommendation and adjusted based on the CONTRACTOR'S CQC Firm's or CONTRACTOR'S experience) in order to establish the percentage of bentonite to be used in production.

D The Infiltration Layer soil source shall be tested by the CONTRACTOR'S CQC Firm during the excavation and stockpiling operation at the frequencies prescribed in Table 2 and/or if changes occur in the material, as identified by the CQA Officer and/or the CONTRACTOR'S CQC Firm, additional tests shall be performed at the cost of the CONTRACTOR.

TABLE 2

Test	Test Method	Frequency
Particle Size Analysis (w/hydrometer every other test)	ASTM D422	Every 10,000 cy
Atterberg Limits	ASTM D4318	Every 10,000 cy
Moisture/Density	ASTM D698	Every 10,000 cy
Natural Moisture	ASTM D2216	Every 10,000 cy
Hydraulic Conductivity on re-molded samples	ASTM D5084	1/borrow source
Shear Strength Test (consolidated un-drained with pore pressure)	ASTM D4767 (or Engineer approved method)	1/borrow source

Results of the tests will be submitted to the ENGINEER within 24 hours of test completion. The ENGINEER can reject material based on the results of the conformance tests. The CONTRACTOR'S CQC Firm will compile all results of the conformance tests and provide a letter report with a summary table of tests results stating that the materials are in conformance. The CONTRACTOR'S CQC Officer shall sign and seal the report.

PART 3: EXECUTION

3.01 TEST PAD

A A test pad of a minimum dimension of approximately 40-ft by 60-ft and 18-in thickness shall be constructed onsite using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The low permeability soil to be used for the test pad shall be

the same material that the CONTRACTOR proposes to use for construction of the Infiltration Layer. If approved by the ENGINEER, the test pad may be installed within the liner limits and incorporated in the work, provided the test pad passes all testing requirements. The test pad testing and results shall not be included in the Quality Control or Quality Assurance testing set forth in 3.04 of this Section.

B The construction of the test pad shall be directed by the CONTRACTOR'S CQC Firm. The CONTRACTOR'S CQC Firm shall use the acceptable zone to set moisture contents and percent compaction. The CONTRACTOR'S CQC Firm will perform tests, as needed, to assist in the construction of the test pad. The OWNER's CQA Firm may also perform testing of the test pad. Both the CONTRACTOR'S CQC and OWNER's CQA field and laboratory testing will be evaluated for determining the performance of the test pad.

C For each lift, the CONTRACTOR'S CQC Firm shall perform testing of moisture content and density at a minimum of three test locations. The Infiltration Layer shall be uniformly compacted to no less than 95% of the standard Proctor (ASTM D698) dry density. If the results of CONTRACTOR'S CQC and OWNER's CQA density testing meet the specification, then two Shelby Tube Samples (ASTM D1587) shall be obtained per lift by the CONTRACTOR'S CQC Firm. One tube will be used for the specified testing and the other tube will held as a backup in a controlled environment at the testing laboratory. One triaxial hydraulic conductivity test (ASTM D5084) will be performed by the CONTRACTOR'S CONTRACTOR'S CQC Firm on each lift of the test pad. These tests will be performed on 3-inch diameter (O.D.) undisturbed samples obtained from a Shelby tube (ASTM D1587) or drive cylinder, trimmed if needed, encapsulated within a flexible latex membrane, and mounted in triaxial type permeameters. The test specimen shall be consolidated under an effective stress of 5 psi and permeated under a back pressure as recommended in paragraph 8.3 of ASTM D5084 to achieve saturation. The hydraulic gradient used for hydraulic conductivity measurements shall be established in the laboratory which will provide for accelerated testing and final results within seven days. The maximum hydraulic gradient shall be performed at the maximum hydraulic gradient (30) according to paragraph 8.5.1 of ASTM D5084 or as specified by the ENGINEER. The hydraulic gradient shall be increased slowly in increments with careful observations of the test sample for consolidation, piping, etc. Test samples that are consolidated in volume by more than 5 percent during the test shall be voided. The inflow and outflow from the sample shall then be monitored and the hydraulic conductivity calculated for each recorded flow increment. The tests will continue until steady state flow is achieved as specified in paragraph 8.5 of ASTM D5084. In addition, the CONTRACTOR'S CQC Firm shall perform one Atterberg Limits Test (ASTM D4318) and one grain size with Hydrometer (ASTM D422) from soil collected adjacent to each permeability sample.

D If the initial test pad does not provide the specified results, additional test pad(s) shall be performed, at the CONTRACTOR'S cost (including CQA costs), until the specified requirements are met.

E For soil-bentonite mixtures, the bentonite content used for the test pad shall be set by the CONTRACTOR and written notification of the mix ratio will be submitted to the ENGINEER prior to constructing the test pad. Any change in mix ratio must be submitted to the ENGINEER before altering soil-bentonite mixture.

F The CONTRACTOR may construct test pads from more than one source of borrow material. However, all costs associated with subsequent test pads shall be paid for by the CONTRACTOR including costs incurred by the OWNER/CQA. If the CONTRACTOR changes the source of borrow for the Infiltration Layer or if the characteristics of the borrow soil within the selected source changes significantly, the ENGINEER may order the construction of additional test pads and subsequent tests as specified above as may be necessary to evaluate the performance of the compacted Infiltration Layer. Construction of additional test pads and the related OWNER's CQA work shall be paid for by the CONTRACTOR.

G The Infiltration Layer thickness shall be determined from three density test locations per lift per test pad using a method consisting of hand augering or push tubes sampling (with a minimum of a 3/4" diameter sample). If the lift thickness is found to be unacceptable by the ENGINEER, the ENGINEER may order the reworking of the lift (addition of material and/or removal of excess material) to provide a uniform lift thickness not to exceed a thickness of 6 inches after compaction.

H All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the CONTRACTOR with bentonite. The CONTRACTOR will provide dry powdered bentonite or bentonite chips for filling holes in the Infiltration Layer.

3.02 INFILTRATION LAYER SUBGRADE

A The established or graded soil cover layer shall be the subgrade for the Infiltration Layer material.

B The subgrade shall be fine graded in accordance with the plans.

C The Infiltration Layer subgrade shall be proofrolled by the CONTRACTOR and examined by the ENGINEER to detect unstable or loose soils. Proofrolling shall be accomplished with a heavy rubber tired piece of equipment subject to ENGINEER approval. The proofrolling must be

witnessed by the OWNER's CQA Firm (to include the RPR). Based on observations during the proofrolling operation, the CQA Officer reserves the right to select the number and direction of passes to be used. Any unsuitable soils encountered at subgrade elevation shall be removed and replaced as directed by the CQA Officer.

D The CQA Officer shall be notified if unpredicted subsurface conditions are encountered during excavation, grading or fill placement. Areas that indicate excessive rutting, pumping, shoving, or movement during proofrolling may require repair. The repair procedure shall be determined by the CQA Officer and will consist of, but not be limited to, removal and replacement of subgrade soils, or replacement with the inclusion of a geogrid, BX-1100 or equivalent, as directed by the CQA Officer.

E The CQA Officer shall observe and approve the subgrade and the survey plan of subgrade elevation submitted by the CONTRACTOR (as per Paragraph 1.03 A6) before installation of the Infiltration Layer can proceed. It shall be the CONTRACTOR'S responsibility to properly prepare and maintain the subgrade in a uniform and compacted condition during installation of the liner.

F If the subgrade is damaged during liner installation, the CONTRACTOR shall restore and re-compact the area to the satisfaction of the CQA Officer prior to installing the liner. All costs related to the restoration of the subgrade shall be paid for by the CONTRACTOR, including re-tests by the CQA Officer.

3.03 INFILTRATION LAYER PLACEMENT

A The CONTRACTOR's CQC Firm and the OWNER's CQA Firm shall conduct field densities, moisture, hydraulic conductivity, Atterberg limits and particle size analysis testing of the in-place Infiltration Layer materials in accordance with the frequencies presented in Section 3.04.

B The placement moisture content shall be within the acceptable zone of moisture content as determined by the CONTRACTOR'S CQC Firm during test pad construction and from the conformance testing of the natural soil or soil-bentonite mixture described in paragraph 2.02 B.

C Water For Compaction

1. The CONTRACTOR is responsible for providing water for construction as required to achieve the required moisture content and guarantee constructability and proper condition of the in-place and stockpiled material.

2. The water shall be of suitable quality from a source approved by the OWNER.

3. Prior to installing the liner, the CONTRACTOR shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the material be stockpiled for any length of time the CONTRACTOR shall slope and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the CONTRACTOR shall spread and dry the material as needed to adjust the moisture to the proper level.

D The Infiltration Layer shall be uniformly compacted to no less than 95% of the standard Proctor (ASTM D698) dry density and within the acceptable zone that corresponds to the placement moisture content. The acceptable zone shall be as specified by the CONTRACTOR'S CQC Firm and approved by the CQA Officer in accordance with the procedures outlined in 2.02 B. Density and moisture shall be uniformly obtained throughout the entire thickness of the liner. The liner shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift. The surface of a lower lift shall be scarified prior to placement of an upper lift. Scarification may include tracking with a bulldozer or making one pass with a sheepsfoot roller. The graded subgrade shall be tracked prior to placement of the initial lift. During placement of the initial lift care should be taken to avoid mixing of the liner material and subgrade material. Therefore, the initial lift should be initially placed and compacted to a thickness of 8 inches and then graded to a total lift thickness of 6 inches. To achieve the specified compaction, the CONTRACTOR shall use a self-propelled compactor such as the Caterpillar 815, or an equivalent, which provides steel kneading feet capable of fully penetrating the loose lift and into the previously compacted lift, (with the exception of the first lift), in spreading and kneading the materials. Finally, a smooth wheel compactor such as a Caterpillar CS553 shall be used with sufficient number of passes to compact, seal, and smooth the upper surface of the Infiltration Layer. All detectable rocks 3 inches or larger shall be removed.

E Liner material shall be disked, harrowed, and kneaded as necessary to break down all clods and produce a uniform material that is free of clods. A clod is defined for the purposes of construction as any subrounded ball of Infiltration Layer material exceeding 1/2 inch in diameter, typically with the core containing less than the specified moisture. If the CQA Officer observes that all clods have not been broken down, the CONTRACTOR shall rework the material to the satisfaction of the CQA Officer.

F Liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated Infiltration Layer materials.

G If a soil-bentonite mixture is to be used, the CONTRACTOR shall use a pugmill or other method of mixing approved by the CQA Officer to produce the soil-bentonite mix at the required moisture content to provide an in place compacted minimum 18-inch thick layer of material as per the drawings with a hydraulic conductivity less than or equal to 1.0×10^{-5} cm/sec. The CONTRACTOR will mechanically screen the soils prior to placement in the pugmill. The pugmill must be approved by the OWNER prior to its arrival on site.

H No Infiltration Layer material shall be placed, spread, or compacted while the subgrade or the Infiltration Layer material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The liner surface must be made smooth and free from ruts, rills, or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation or ponding on the liner material. Any re-grading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift. Thickness measurements should be performed as indicated in Paragraph 3.04 of this Section. Areas previously meeting the conformance test requirements that are reworked in excess of the top 3-inch per lift shall be retested. Re-testing will be performed the cost of the Contractor for density/moisture and permeability as needed to comply with Section 3.04. Additionally, the CQA Officer may request retesting for surface reworked areas if, at the discretion of the CQA Officer, the compacted soil layer material does not appear to be in accordance with these specifications

I Work shall be limited to an area where a lift can be completed in one working day.

J If a lift is not to receive a subsequent lift within 16 hours of its completion, the lift shall be sealed with a smooth drum compactor, such as the Caterpillar CS553, at the end of each day's work to protect the liner from desiccation. Should desiccation cracks develop, the liner shall be scarified, disked, rewetted, re-homogenized and re-compacted in accordance with the Specifications to the depth of any such cracks or as instructed by the CQA Officer. If desiccation extends below 1/2 the lift thickness, the lift shall be removed and the lower lift scarified, moisturized, re-compacted and re-tested as necessary as approved by the CQA Officer at the cost of the CONTRACTOR including retests.

K During construction, the CONTRACTOR shall make all necessary provisions to deal with inclement weather conditions. The CONTRACTOR

shall be fully responsible for control of stormwater during installation of the liner system and for moisture control and protection of the Infiltration Layer.

L After finish grading and smooth rolling is completed, the Infiltration Layer shall not be less than 18-inches in any location. Completed liner thickness will be determined from survey per Section 01050 1.03C. The thickness shall be measured from top of subgrade to the top of the Infiltration Layer. Areas not meeting the thickness requirements shall be augmented with additional Infiltration Layer material at the expense of the CONTRACTOR. Any additional testing or other CQA services associated with corrective action for achieving the 18-inch liner thickness requirement will be at the cost of the CONTRACTOR. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. At a minimum, the top 3-inches of the liner shall be wetted, kneaded, compacted and re-worked with the additional material to obtain the required thickness. Additional testing including, but not limited to, density/moisture testing and permeability testing shall be performed by the CONTRACTOR'S CQC Firm at the discretion of the CQA Officer. Liner thickness will be spot checked by the CONTRACTOR'S CQC Firm on a per-lift basis at a frequency specified in 3.04 of this Section using a method of hand augering or push tube sampling. Each test shall penetrate all underlying lifts to the subgrade elevation. All test holes must be filled with powdered bentonite provided by the CONTRACTOR. Only the CONTRACTOR'S survey will be considered for confirming the specified Infiltration Layer thickness.

3.04 QUALITY CONTROL AND QUALITY ASSURANCE DURING PLACEMENT

A The CONTRACTOR'S CQC Firm and the OWNER's CQA Firm shall conduct tests during installation of the natural Infiltration Layer at the minimum frequencies specified in Table 3 (following page).

TABLE 3

TEST	METHOD	FREQUENCY	
		CQC	CQA
Particle Size Analysis w/Hydrometer every other test	ASTM D422	1 per acre	1 per 4 acres
Atterberg Limits	ASTM D4318	1 per acre	1 per 4 acres
Undisturbed Permeability	ASTM D5084	1 per acre	1 per 4 acres
Field Density	ASTM D2922	4 per acre/lift	1 per 2 acres
Natural Moisture	ASTM D3017	4 per acre/lift	1 per 2 acres
Liner thickness	Hand Auger or push tube	4 per acre/lift	1 per 2 acres

B One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

C A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

D All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the CONTRACTOR with bentonite as instructed by the CQA Officer. The CONTRACTOR will provide dry powdered bentonite or bentonite chips for filling holes in the Infiltration Layer.

E The CQA Officer shall have the authority to request additional permeability tests in areas that, in the CQA Officer's judgment, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 3.01-C. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. The sample will be held in a controlled environment at the OWNER's CQA Firm's testing laboratory as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the Infiltration Layer or that an error in testing occurred, the backup sample will be tested and the original test will be disregarded.

F Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas. The CQA Officer will determine the extent of reconstruction of the Infiltration Layer based on laboratory test information and field test results. Any retest associated with re-worked areas will be at the cost of the CONTRACTOR.

G The CONTRACTOR shall submit a survey plan with subgrade elevation, top of Infiltration Layer, and top of Protective Cover for CQA Officer's approval in accordance with Section 01050.

3.05 CORRECTIVE ACTION

If in-place Infiltration Layer material has been desiccated to a depth less than or equal to ½ the lift thickness, the desiccated lift shall be disked, moistened, and re-compacted. However, disking may produce large, hard clods of Infiltration Layer that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods of Infiltration Layer and hydration to take place uniformly. For this reason it may be necessary to remove the desiccated soil from the construction area, to process the lift in a separate processing area, and to replace the soil accordingly.

If in-place Infiltration Layer material desiccation extends below 1/2 the lift thickness, the lift shall be removed and the lower lift scarified, moisturized, re-compacted and retested as necessary as approved by the CQA Officer at the cost of the CONTRACTOR including retests.

3.06 REPORTING

A The CONTRACTOR's CQC Officer shall provide a final Construction Quality Control Report for the Infiltration Layer at the end of the project. The report shall certify that the Infiltration Layer work was performed in accordance with the Contract Documents and be prepared and sealed by a Professional Engineer registered in the State of South Carolina. The report shall include a discussion of the methodology of the test pad and liner construction, a

discussion of the test methods and frequency performed by the CQC representative, summary tables of all field and laboratory test results, including location and notations regarding any re-work performed, as appropriate, and daily field reports including daily field tests.

END OF SECTION

SECTION 02505

CRUSHED STONE PAVING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A The Contractor shall furnish all labor, materials, equipment and incidentals required to construct access and service roads as shown on the Drawings.

B The Contractor shall maintain access and service roads under this Contract during the guarantee period of one year and shall promptly re-fill and grade areas that have settled or are otherwise unsatisfactory for traffic.

1.02 RELATED WORK NOT INCLUDED

A Section 02200: Excavation, Backfill, and Compaction

B Section 02272: Filter Fabric

1.03 REFERENCE SPECIFICATIONS

A Except as otherwise specified herein, the Standard Specifications for Highway Construction as issued by the State of South Carolina, Department of Transportation, shall apply to material requirements for access and service road construction.

1.04 SUBMITTALS

A The contractor shall submit to the Engineer one 50-lb sample of the proposed graded aggregate base course material and certification statement from the source or manufacturer with the results of recent gradation and modified Proctor moisture-density tests performed by SCDOT or from the Department approved source for which the material is manufactured.

B The contractor shall submit to the Engineer, a manufacturer's certification statement that the geotextile conforms to the material specified for this application on the detailed drawings or as specified in Section 02272.

PART 2 - PRODUCTS

2.01 SUBGRADE MATERIAL

A Subgrade in cut areas shall consist of firm, hard natural soils and shall be proofrolled as described in Section 3.02. Subgrade in fill areas shall consist of Select Fill, as defined in Section 02200 and compacted to at least 98 percent of its standard Proctor (ASTM D698) maximum dry density.

2.02 CRUSHED STONE

A Crushed Stone paving material shall conform to SCDOT standards for graded aggregate base and shall be compacted to at least 98 percent of the maximum dry density as determined by AASHTO T 180 or equivalent.

2.03 GEOTEXTILE

A Geotextile fabric shall be installed under the crushed stone according to the detailed drawings.

PART 3 - EXECUTION

3.01 GENERAL

A Materials for the access roads shall be delivered, placed and compacted in accordance with the contract specifications and drawings.

B The Contractor shall perform all general unclassified excavation, rough or overall grading, borrow and fill, to the subgrades of the road, road shoulders and slopes to match the existing grades.

C Finished excavation and grading shall be uniformly smooth, well compacted, and free from irregular surface changes. The degree of finish shall be that obtainable from either blade-grader or scraper operations. The finished surface shall not be more than 0.10 ft above or below the new grade.

3.02 INSTALLATION

A Prior to placing backfill to construct the pavement subgrade in fill areas, or Crushed Stone paving in cut areas, the exposed natural soil subgrade shall be proofrolled in the presence of the CQA Representative. Proofrolling shall be performed with at least four complete passes of a loaded 30 Ton articulated end dump truck or equivalent or as directed by the Engineer. Soft, wet, organic, or other unsuitable materials or conditions identified during proofrolling shall be undercut by at least 12 inches and backfilled with suitable fill as directed by the Engineer at no additional cost to the OWNER.

B Backfill fill for pavement subgrade shall be placed in layers in accordance with Section 02200 and compacted to at least 98% of its standard Proctor (ASTM D698) maximum dry density. CQC shall perform compaction testing of the select fill.

C Geotextile (separation layer) shall be installed on the subgrade according to the detailed drawings

D Crushed Stone paving shall be placed over the prepared subgrade and overlying geotextile where shown on the contract documents. The first lift of Crushed Stone shall be at least 8-inches-thick and less than 10-inches-thick. The Crushed Stone shall be spread with track-mounted equipment. Subsequent lifts of Crushed Stone shall have a maximum loose-lift thickness of 8-inches. Each lift of Crushed Stone shall be compacted to at least 98% of its maximum dry density as determined by AASHTO T 180 or equivalent. CQC shall perform compaction testing of the crushed stone paving. The frequency of testing for the Crushed Stone Paving shall be at minimum, 1 test per lift per 10,000 square feet or as otherwise directed by the Engineer. The QC Firm shall provide all testing data to the CQA Officer within 24-hours, in summary form.

Crushed stone paving shall conform to the grades represented on the Drawings. The surface shall be graded with positive drainage as to not impound water.

END OF SECTION

SECTION 02589

GEOMEMBRANE LEAK LOCATION SURVEY

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Requirements for performance of a geomembrane leak location survey using electrical methods for post-geomembrane installation performance for a geomembrane covered with geocomposite or geotextile and earth materials and underlain by earth materials.

B. Requirement to perform a geomembrane leak location survey after protective cover material is placed on the geocomposite or geotextile and geomembrane. The leak location survey is conducted after the geocomposite or geotextile and protective cover materials are installed to detect leaks resulting from construction damage caused during placement of the protective cover layer.

C. The optimum performance of a geomembrane leak location survey using electrical methods requires the conductive media above and below the geomembrane to be electrically isolated from each other except through the leaks being located in the geomembrane. It is also necessary to have a continuous electrically conducting pathway through an electrically conducting material above the geomembrane, through the leaks, and through an electrically conducting media under the geomembrane.

1.02 RELATED SECTIONS

A. Section 02275: Compacted Soil Liner

B. Section 02776: Textured High Density Polyethylene (HDPE) Liner

C. Section 02274: Geocomposite Drainage Net

D. Section 02700: Protective Cover

1.03 REFERENCES

A. ASTM D 6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

B. ASTM D 7007 – Standard Practices for Locating Leaks in Geomembranes Covered with Water or Earth Materials

1.04 SUBMITTALS

A. CONTRACTOR shall submit a Leak Location Survey Work Plan to the Engineer for approval prior to commencement of the leak location survey. The Leak Location Survey Work Plan shall include:

1. Qualifications of the proposed Leak Location Contractor to include the number of years the Leak Location Contractor has performed the proposed survey methods;

2. Resumes of proposed on-site supervisors;

3. Description of the proposed survey methods and procedures, site preparations, and planned duration of the Work;

4. Quality control and field calibration procedures;

5. A list of projects demonstrating the qualifications and experience where the proposed Leak Location Contractor and leak location supervisor has met the requirements of paragraph 2.1 of this specification.

6. Sample of a final report (per ASTM D 7007) provided by the Leak Location Contractor following the completion of the survey.

1.05 CONSTRUCTION QUALITY ASSURANCE

A. The leak location survey shall be observed by the CQA Officer.

B. The CONTRACTOR shall be aware of the leak location survey work plan and activities outlined herein and shall account for these activities in the construction schedule.

PART 2: PRODUCTS

2.01 LEAK LOCATION CONTRACTOR AND SUPERVISOR QUALIFICATIONS

A. The Leak Location Contractor shall have qualifications and experience in conducting the proposed survey method including having tested a minimum of 15,000,000 square feet of geomembrane liner within the previous three years. In addition, the leak location surveys must be supervised by a professional or technician with a minimum of three years and 1,000,000 square feet of liner testing experience using the proposed leak location survey methods. The leak location supervisor must be on-site full-time during the performance of the leak location survey.

PART 3: EXECUTION

3.01 INFORMATION REQUIRED

A. The Engineer shall provide the Leak Location Contractor with drawings showing:

1. All layers constituting the lining system and details of all liner penetrations.

3. Peripheral details, including welds to adjacent lining systems.

4. Structures and obstructions above the liner.

3.02 SITE PREPARATION

A. Leak Location Contractor will identify actions required by CONTRACTOR to prepare the site for the leak location survey.

B. CONTRACTOR shall ensure that the earth materials above and below the geomembrane contain sufficient moisture to conduct a leak location survey. Typically, a moisture content of the earth materials of one to two percent by weight is sufficient to conduct the survey. If the moisture content of the earth materials layer is not sufficient per the requirements of the Leak Location Contractor, then the Contractor shall add sufficient water to the earth materials as required.

C. CONTRACTOR shall provide electrical isolation around the perimeter of the area being surveyed for leaks. Electrical isolation is achieved by leaving approximately a one-foot wide area of dry geomembrane exposed around the perimeter of the section or leaving a minimum of six-inches of bare liner protruding from the back-filled anchor trench. Any other electrically conducting paths through the geomembrane such as metal pipes, battens, or concrete structures should be likewise isolated.

3.03 EXECUTION

A. The Leak Location Contractor shall inspect the site prior to commencing the survey to ensure all site preparations are completed and the site conditions are appropriate for conducting the leak location survey.

B. Any discrepancy in the required site preparation described in the Leak Location Survey Work Plan or site conditions shall be reported to the Contractor for corrective or appropriate action.

C. After the protective cover is added above the geomembrane, conduct a leak location survey on the earth materials using the procedures for surveys with

earth materials covering the geomembrane described in the latest version of ASTM Standard D 7007.

D. The Leak Location Contractor shall inform the Engineer and mark the locations of all identified or indicated leaks with markers, flags, spray paint, or written coordinates.

E. The CONTRACTOR shall, in the presence of the CQA Officer and/or their on-site representatives, shall expose the geomembrane at the identified or indicated leak locations, inspect the leak, and repair the leak in a manner acceptable to the Engineer. Repairs to the geomembrane shall be performed by the geomembrane installer. Non-destructive air testing shall be performed on the repair.

3.04 REPORTING

A. Provide a written report to the Engineer within 14 calendar days of completion of the leak location survey field work as described in ASTM D 7007.

END OF SECTION

SECTION 02623

HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install high density polyethylene leachate pipe, fittings and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02776: High Density Polyethylene (HDPE) Liner

B Section 02700: Protective Cover

C Section 02271: Fabric Cushion

D Section 02200: Excavation, Backfill, and Compaction

1.03 SUBMITTALS

A Within 30 days following the Effective Date of the Agreement, submit the following information in accordance with Section 01340:

1. List of materials to be furnished, the names of the suppliers and the scheduled date of delivery of materials to the site.

2. The origin of the resin to be used in the manufacturing of the pipe including the suppliers name and production plant, as well as brand name and number.

3. Documentation from the resin's manufacturer showing results of tests for resin identification, including:

   a. Melt Flow Index ASTM D1238

   b. Density ASTM D1505

4. Manufacturer quality control manual describing implementation of quality control procedures during pipe manufacturing process.

5. Pipe Manufacturer's Certification of compliance with these Specifications.

6. Complete, detailed shop drawings of all polyethylene pipe and appurtenances, including the location of all fittings, joints and connections to structures.

7. Manufacturer's recommendations for handling, storing and installing pipe and fittings.

8. For each shipment of pipe a manufacturer's certification that the pipe was manufactured from the same resin identified in Paragraph 1.03.A1.

9. Certification demonstrating that the joining technician was trained by the pipe manufacturer and is qualified to perform heat fusion welding.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D1238 - Standard Test Method for Flow Rates Thermoplastics by Extrusion Plastometer.

2. ASTM D1248 - Standard Specification for Polyethylene Plastic Molding and Extrusion Materials.

3. ASTM D1505 - Standard Test Method for Density of Plastic by the Density Gradient Technique.

4. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

5. ASTM D3350 - Specification for Polyethylene Plastic Pipe and Fitting Materials.

6. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

B Where reference is made to one of the above standards, the revision in effect at the time of construction shall apply.

1.05 QUALITY ASSURANCE

A Resin Evaluation

1. All incoming resin shall be sampled for conformance testing against test results supplied by the resin manufacturer. Samples shall be taken from the top and bottom of each compartment from every hopper car received. The following conformance tests shall be performed on the sample:

a.	Melt Flow Index	ASTM D1238
b.	Density	ASTM D1505

The results of these tests shall become part of the manufacturer's permanent quality control records.

B Finished Product Evaluation

1. Each length of pipe produced shall be checked by production staff for the items listed below. The results of all measurements shall be recorded on production sheets which become part of the manufacturer's permanent records.

   a. Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc).

   b. Pipe outside diameter shall be measured using a suitable periphery tape to ensure conformance with ASTM F714.

   c. Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with ASTM F714.

   d. Pipe length shall be measured.

   e. Pipe marking shall be examined and checked for accuracy.

   f. Pipe ends shall be checked to ensure they are cut square and clean.

   g. Subject inside surface to a "reverse bend test" to ensure the pipe is free of oxidation (brittleness).

C Stress Regression Testing

1. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific polyethylene resin being utilized in the manufacture of this product. This stress regression testing shall have been done in accordance with ASTM D2837 and the manufacturer shall provide a product supplying a minimum Hydrostatic Design Basis (HDB) of 1,600 psi as determined in accordance with ASTM D2837.

1.06 WARRANTY

A The pipe material manufacturer shall provide an unconditional extended warranty for the pipe covering the cost of materials for repair or replacement plus installation manpower should the pipe fail within the warranty period. The manufacturer's extended warranty shall be for ten years after the final acceptance of the project by the OWNER. The manufacturer shall guarantee that the pipe furnished is suitable for the purpose intended and free from

defects of material and workmanship for the duration of the extended warranty. In the event the pipe fails to perform as specified, the pipe manufacturer shall promptly replace defective pipe without any cost to the OWNER.

PART 2: PRODUCT

2.01 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A The pipe supplied shall be high density, high molecular weight, polyethylene (HDPE) pipe. The pipe shall conform to ASTM D3350 with a minimum cell classification value of 345434C.

B All fittings shall be made from polyethylene resin which meets this same specification as in 2.01A.

C HDPE pipe shall be Standard Dimension Ratio SDR 13.5.

D All polyethylene pipes shall meet the requirements of ASTM F714.

E Pipe shall be furnished in standard laying lengths not exceeding 50 feet.

2.02 PIPE IDENTIFICATION

A The following shall be continuously printed on the pipe or spaced at intervals not exceeding 5-ft:

1. Name and/or trademark of the pipe manufacturer.
2. Nominal pipe size.
3. Dimension ratio.
4. The letters PE followed by the polyethylene grade in accordance with ASTM D1248, followed by the hydrostatic design basis in 100's of psi, e.g., PE 3408, PE 4710.
5. Manufacturing standard reference, e.g., ASTM F714.
6. A production code from which the date and place of manufacture can be determined.

2.03 PERFORATIONS

A PERFORATED PIPE: locations for perforated pipe, perforation sizes and hole patterns are detailed in the Contract Drawings.

B For accuracy and uniformity, the pipe shall be drilled to design specifications by machines designed for perforating pipe.

PART 3: EXECUTION

3.01 INSTALLATION

A High Density Polyethylene (HDPE) Pipe shall be installed in accordance with the instruction of the manufacturer, as shown on the Drawings and as specified herein. All heat fusion joints shall be done by a qualified joining technician as designated by the pipe manufacturer.

B Pipe shall be laid to lines and grade shown on the Drawings with bedding and backfill as shown on the Drawings.

C PERFORATED PIPE: Tape covering perforations shall be removed during installation. The pipe shall be installed such that perforations face the bottom of trench. The perforations of pipe sections shall be aligned when connected. The pipe shall be joined by butt fusion or by a method of coupling as approved by the ENGINEER.

D When installation is not in progress, including breaks in work, the open ends of the pipe shall be closed by fabricated plugs, or by other approved means.

E HANDLING OF PIPE: Pipe shall be stored on clean level ground to prevent undue scratching or gouging. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp or rough objects and/or areas. The maximum allowable depth of cuts, scratches or gouges on the exterior of the pipe is 10 percent of wall thickness. The interior pipe surface shall be free of cuts, gouges or scratches.

F REPAIR OF PIPE: Sections of pipe with cuts, scratches or gouges deeper than allowed shall be removed completely and the undamaged sections of the pipe re-joined.

G JOINING: The pipe shall be joined by the method of thermal butt fusion, as outlined in ASTM D2657. All joints shall be made in strict compliance with the manufacturer's recommendations. In locations where butt fusion cannot be achieved (ex. tie-in to bootless pipe penetration), a thermal coupling such as electrofusion connections may be used as approved by the ENGINEER. Hot air welding is not permitted.

H MECHANICAL CONNECTIONS: Flange adaptors shall be used to connect pipe to auxiliary equipment such as valves, pumps and tanks, and shall consist of the following:

1. A stainless steel back-up, polyethylene flange shall be thermally butt-fused to the stub end of the pipe.

2. A 316 stainless steel back up ring on both sides of the connection shall be used as approved by the ENGINEER.

3. Flange connections shall be provided with a full face neoprene gasket.

I Fused segments of the pipe shall be handled so as to avoid damage to the pipe. Chains or cable type chokers must be avoided when lifting fused sections of pipe. Nylon slings are preferred. Spreader bars are recommended when lifting long fused sections.

J BACKFILLING: All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

K Installation of pipe shall be observed and accepted by the CQA Officer prior to backfilling.

3.02 TESTING

A All non-perforated pipe shall be field tested (with the exception of non-perforated cleanouts). The CONTRACTOR shall supply all labor, equipment, material, gages, pumps, meters and incidentals required for testing.

B All non-perforated pipe shall be tested at a pressure of 130 psi. The test pressure shall be measured at the highest point along the test section by a recording type pressure gage and a copy of the readout shall be submitted to the ENGINEER upon completion of the test. All testing shall be conducted in the presence of the ENGINEER or the RPR.

C Testing shall be conducted after backfilling has been completed and before placement of permanent surface.

D Testing procedure shall be as follows:

1. Fill line slowly with water; maintain flow velocity less than two feet per second.

2. Expel air completely from the line during filling and again before applying test pressure.

3. Apply initial test pressure and allow to stand without makeup pressure for three hours, to allow for diametric expansion or pipe stretching to stabilize.

4. After this equilibrium period, apply the specified test pressure and turn the pump off. The final test pressure shall be held for three hours.

5. Upon completion of the test, the pressure shall be bled off from a location other than the point where the pressure is monitored. The pressure drop shall be witnessed by the RPR. The point where the pressure is being monitored shall show on the recorded pressure read-out submitted to the ENGINEER.

E Allowable amount of makeup water for expansion during the pressure test shall conform to Table 5, Allowance for Expansion Under Test Pressure, Technical Report TR 31/88, published by the Plastic Pipe Institute (PPI). If there are no visual leaks or significant pressure drops during the final test period, the installed pipe passes the test.

F If any test of pipe laid disclosed leakage or significant pressure drop greater than that allowed, the CONTRACTOR shall, at his/her own expense, locate and repair the cause of leakage and retest the line.

G All visible leaks are to be repaired by an approved method, regardless of the amount of leakage.

3.03 CLEANING

A At the conclusion of the work, thoroughly clean all of the new pipelines to remove all dirt, stones, and pieces of wood or other material that may have entered during the construction period. Debris cleaned from the lines shall be removed from the job site. If, after this cleaning, any obstructions remain, they shall be removed.

B Special attention shall be given to clean free and remove HDPE shavings and particles resultant of fusion welding activities. Any area where these activities occurred shall be inspected by the CQA Representative and Contractor prior to acceptance of the Work; this includes sump areas, header line areas and low points of drainage.

END OF SECTION

SECTION 02625

CORRUGATED POLYETHYLENE PIPE

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install corrugated polyethylene pipe, couplings, fittings and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill, and Compaction

B Section 02701: Drainage and Erosion Layer

1.03 SUBMITTALS

A Within 30 days following the Effective Date of the Agreement, submit the following information in accordance with Section 01340:

1. List of materials to be furnished, the names of the suppliers and the date of delivery of materials to the site.

2. Pipe manufacturer's certification of compliance with these Specifications for each type of pipe furnished.

3. Complete, detailed shop drawings of all polyethylene pipe, including the location of all fittings, joints, elbows, connections to structures, and flared- end sections.

4. Manufacturer's recommendations for handling, storing and installing pipe and fittings.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D168 - Conditioning Plastics and Electrical Insulating Materials for Testing.

2. ASTM D883 - Terms Relating to Plastics.

3. ASTM D1693 - Environmental Stress Cracking of Ethylene Plastics.

4. ASTM D2122 - Determination of Thermoplastic Pipe and Fittings.

5. ASTM D2412 - Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

6. ASTM D2444 - Test for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).

7. ASTM D3550 - Standard Specification for Polyethylene Plastics Pipe and Fitting Materials.

8. ASTM F412 - Terms Relating to Plastic Piping Systems.

9. AASHTO Standard - Standard Specification for Highway Bridges - M294

10. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe 12" to 36" Diameter.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A Finished Product Evaluation

1. Each length of pipe produced shall be checked by production staff in accordance with AASHTO M-294. The results of all measurements shall be recorded on production sheets which become part of the manufacturer's permanent records and at a minimum shall include:

   a. Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc).

   b. Pipe inside diameter shall be measured in accordance with ASTM D2122.

   c. Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with ASTM F714.

   d. Pipe length shall be measured.

   e. Pipe marking shall be examined and checked for accuracy.

   f. Pipe ends shall be checked to ensure they are cut square and clean.

g. Subject inside surface to a "reverse bend test" to ensure the pipe is free of oxidation (brittleness).

B Pipe Testing

1. The polyethylene pipe manufacturer shall provide certification that testing has been performed for the following: Pipe stiffness (ASTM S2412), brittleness (ASTM D2444), environmental stress cracking (ASTM D1693).

1.06 WARRANTY

A The pipe material manufacturer shall provide a warranty for the pipe covering the cost of materials for repair or replacement should the pipe fail. The manufacturer shall guarantee that the pipe furnished is suitable for the purpose intended and free from defects of material and workmanship. In the event the pipe fails to perform as specified, the pipe manufacturer shall promptly replace defective pipe in accordance with the manufacturer's warranty without any cost to the OWNER

PART 2: PRODUCT

2.01 CORRUGATED POLYETHYLENE (PE) PIPE

A Corrugated polyethylene pipe shall conform to the following: AASHTO M-294.

B Corrugated Polyethylene (PE) Pipe shall be manufactured from high-density polyethylene (HDPE) virgin compounds and shall conform to the cell classifications as listed in AASHTO M 294.

C All corrugated polyethylene pipe shall be manufactured with annular corrugation conforming to AASHTO M-294.

D All joints shall be made in strict compliance with the manufacturer's recommendations.

E Pipe shall be furnished in standard laying lengths not exceeding 50 feet.

F The Corrugated Polyethylene Pipe covered by this specification is classified as follows:

1. Type S - This pipe shall have a full circular cross-section, with an outer corrugated pipe wall and a smooth interior. Joints shall be integrated bell and spigot with ASTM F477 rubber gasket on spigot end. Pipe and bell must be of one homogeneously molded piece. Welded or friction bells will not be accepted.

G Repair coupling bands and fitting connections for corrugated polyethylene pipe shall demonstrate soil tightness requirements of AASHTO section 26.4.2.4, "Standard Specifications for Highway Bridges". Coupling bands shall lap equally on each side of the pipe or fittings being connected to form a tightly closed joint after installation. The corrugations in the band shall index the corrugations in the pipe or fitting ends to engage the first or second corrugation from the end of each pipe or fitting.

2.02 PIPE IDENTIFICATION

A The following shall be continuously printed on the pipe or spaced at intervals not exceeding 5-ft:

1. Name and/or trademark of the pipe manufacturer.

2. Nominal pipe size.

3. Dimension ratio, class, and AASHTO designation.

4. The letters PE followed by the polyethylene grade in accordance with ASTM standards.

5. Manufacturing standard reference, e.g., ASTM F714.

6. A production code from which the date and place of manufacture can be determined.

PART 3: EXECUTION

3.01 INSTALLATION

A Polyethylene (PE) Pipe shall be installed in accordance with the instruction of the manufacturer, as shown on the Drawings and as specified herein.

B Pipe shall be laid to lines and grade shown on the Drawings with bedding and backfill as shown on the Drawings. The tape covering the perforations shall be removed during installation. The pipe shall be installed such that perforations face the bottom of trench.

C When installation is not in progress, including lunchtime, the open ends of the pipe shall be capped or covered by rubber gasket pipe plugs, such as ADS type 2433AA or other approved Engineer approved method.

D Pipe shall be stored on clean level ground to prevent undue scratching or gouging. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. The maximum allowable depth of cuts, scratches or gouges on the exterior of the pipe is 10

percent of wall thickness. The interior pipe surface shall be free of cuts, gouges or scratches.

E Sections of pipe with cuts, scratches or gouges deeper than allowed shall be removed completely and the ends of the pipeline rejoined.

F All joints shall be made in strict compliance with the manufacturer's recommendations.

G Mechanical connections of the polyethylene pipe to auxiliary equipment such as valves, pumps and tanks shall be through flanged connections which shall consist of the following:

1. A stainless steel back-up, polyethylene flange shall be thermally butt-fused to the stub end of the pipe.

2. A 316 stainless steel back up ring on both sides of the connection shall be used as approved by the CQA Officer.

H Flange connections shall be provided with a full face neoprene gasket.

I All PE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

J Installation of pipe shall be observed and accepted by the CQA Officer (RPR) prior to backfilling.

3.02 CLEANING

A At the conclusion of the work, thoroughly clean all of the new pipe lines to remove all dirt, stones, pieces of wood or other material which may have entered during the construction period. Debris cleaned from the lines shall be removed from the job site. If, after this cleaning, any obstructions remain, they shall be removed.

END OF SECTION

SECTION 02700

PROTECTIVE COVER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install the protective cover soil materials associated with the leachate collection system and protective cover layer over the textured HDPE base liner as shown on the Drawings and as specified herein. Associated work includes sample collection and testing, excavation, loading, hauling, and installation of granular fill materials.

B The protective cover layer consists of 24-inches of material placed over a composite drainage net (filter fabric bonded to both sides of drainage net). Leachate collection pipes surrounded by SCDOT No. 67 stone, No. 789 stone, and C-33 sand will be constructed in the protective cover layer. The locations of leachate collection pipes and details showing the protective cover layer are indicated on the Contract Drawings. The protective cover soil, granular materials and sand are specified in this Section. The leachate collection pipes, fabric cushion, and composite drainage net are specified in the Sections listed in paragraph 1.02.

1.02 RELATED WORK

A	Section 02200:	Excavation, Backfill, and Compaction
B	Section 02271:	Fabric Cushion
C	Section 02274:	Geocomposite Drainage Net
D	Section 02623:	High Density Polyethylene Pipe
E	Section 02776:	Textured High Density Polyethylene (HDPE) Liner

1.03 SUBMITTALS

A Within 30 calendar days following the Effective Date of the Agreement and before installing the protective cover materials, the CONTRACTOR shall submit the following information in accordance with Section 01340:

1. Identification of the suppliers for each protective cover soil material.

2. A signed certification letter, with all necessary permits, that the material source or sources, is in full compliance with State, County, and local laws and regulations.

3. A schedule and description of the procedures and equipment for installation of the protective cover layer and leachate collection system.

4. A Quality Control Plan for the protective cover layer and leachate collection system installation.

5. Documentation and related past experience in accordance with Paragraph 1.06.

6. One 75-pound sample for laboratory testing from each soil material to be used for the protective cover layer and leachate collection system.

7. A substantially complete record drawing of the installed HDPE liner approved by the Engineer.

B Within four weeks after completion of the protective cover layer and leachate collection system installation, the CONTRACTOR shall submit to the ENGINEER a survey plan certified by a Land Surveyor Registered in the State of South Carolina showing the elevations of the top of the protective cover layer.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM C33 - Standard for Fine Concrete Aggregate.

2. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

3. ASTM D698 - Standard Test Methods for Moisture-Density Relationship of Soil and Soil-Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

4. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

5. ASTM D2992 - Density of soil in place by nuclear methods (Shallow Depth).

6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

7. ASTM D4254 - Standard Test Methods for Minimum Index Density of Soils and Calculation of Relative Density.

8. ASTM C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

9. ASTM C136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

10. ASTM C289 - Standard Test Method for Potential Reactivity of Aggregates (Chemical Method).

11. ASTM D75 - Standard Practice for Sampling Aggregates.

12. ASTM D3042 - Standard Test Method for Insoluble Residue in Carbonate Aggregate.

13. ASTM D4373 - Standard Test Method for Calcium Carbonate Content of Soils.

14. ASTM 2434 - Permeability of granular soils by constant head tests.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE / QUALITY CONTROL

A The Quality Control and Quality Assurance consists of laboratory conformance testing of samples supplied from each soil material and quality control testing during installation.

B The CONTRACTOR will retain a CQC Officer and a Quality Control Laboratory (QCL) that has appropriate equipment and experience to conduct and provide the test results in a timely manner in accordance with the Specifications. The CONTRACTOR shall coordinate and schedule all tests as required.

C Conformance testing requirements are specified in Paragraph 2.02. The purpose of conformance testing is to assure that the supplied samples from each source conform to the Specifications.

D Field quality control requirements are specified in Paragraph 3.02. The purpose of field quality control procedures is to assure that the protective cover and leachate collection system have been installed in accordance with the specifications meeting the specified hydraulic conductivity.

1.06 QUALIFICATIONS

A The work shall be performed by a contractor that has experience in installation of leachate collection systems and protective cover soil materials over

geosynthetic liners. The CONTRACTOR shall demonstrate proven experience by providing a minimum of one similar completed project with the following information:

1. Types and thicknesses of installed materials.

2. Name and purpose of facility, its location, and date of installation.

3. Name of owner and design engineer. Name and telephone number of contact at the facility that can discuss the project.

B The CONTRACTOR demonstrate that material suppliers or sources will provide adequate supplies of each soil material to be provided within the schedule of construction and evidence that each source area can provide homogenous material and is properly permitted by the appropriate local, State and Federal agencies.

1.07 DELIVERY, STORAGE AND HANDLING

A If materials are delivered to the site prior to placement approval, materials shall be stockpiled on site in areas as approved by the Owner and/or CQA Officer. Provision shall be implemented to minimize surface water impact on the stockpile. Removal and placement of granular fill material shall be done in a manner to minimize intrusion of soils adjacent to and beneath the stockpile.

PART 2: PRODUCT

2.01 MATERIAL

A SCDOT No. 67 Stone and SCDOT No. 789 Stone

Washed rounded or sub-rounded stone meeting the gradation requirements of South Carolina Department of Transportation (SCDOT) No. 67 and No. 789 Stone to be used for filtration around the leachate collection pipes, as shown on the Drawings. SCDOT No. 67 and No. 789 Stone shall be sound, hard, durable and resistant to weathering, and shall be free of overburden, spoil, shale, limestone and organic material.

B C-33 Sand

C-33 Sand shall be used for filtration near the leachate collection pipes, as shown in the Drawings. C-33 sand shall be inorganic, non-calcareous granular soil material, free from organic matter and other deleterious material with particle size gradation (ASTM D422) within the limits in Table 1:

TABLE 1

Sieve Size	Percent Passing by Weight (%)
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	45-95
No. 30	25-75
No. 50	8-30
No. 100	0.5-10
No. 200	0-3

C-33 Sand shall have a minimum permeability of $1x10^{-3}$ cm/sec or greater when compacted to 90 percent of standard Proctor maximum dry density (ASTM D698).

C Protective Cover

Protective Cover shall be inorganic, non-calcareous granular soil material, free from organic matter and other deleterious materials with particle size gradation (ASTM D422) within the limits in Table 2:

TABLE 2

Sieve Size	Percent Passing by Weight (%)
3/8"	100
No. 4	80-100
No. 200	0-20

Protective Cover shall have a minimum permeability of 1×10^{-4} cm/sec or greater when compacted to 95 percent of standard Proctor maximum dry density (ASTM D698).

2.02 CONFORMANCE TESTING

A The CONTRACTOR shall collect samples of protective cover material and C-33 sand from the proposed borrow sources for testing by the CQC Laboratory. If the samples do not meet the specified criteria, the CONTRACTOR may

submit additional samples from other sources for conformance testing by the CQC Laboratory at the CONTRACTOR's expense.

B The protective cover and C-33 sand shall be tested by the CQC Officer at the frequencies specified in Table 3. If changes in material, as identified by the ENGINEER, occur within the frequency prescribed below, additional tests shall be performed at the expense of the CONTRACTOR.

TABLE 3

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	Every 15,000 cy
Moisture/Density	ASTM D698	Every 15,000 cy
Natural Moisture	ASTM D2216	Every 15,000 cy
Permeability (remolded)	ASTM 2434	Every 15,000 cy

Results of the tests shall be submitted to the ENGINEER within 24 hours of test completion. The ENGINEER reserves the right to reject material based on the results of the conformance tests.

C Gradation analyses shall be performed by the CQC Laboratory on samples from each source of SCDOT No. 67 and SCDOT No.789 stone to assure compliance with the Specifications.

PART 3: EXECUTION

3.01 PROTECTIVE COVER SOIL MATERIAL PLACEMENT

A After installation completion and acceptance of the HDPE liner, geocomposite drainage net and related work activities, place the protective cover soil materials to thicknesses and areal extent as shown on the Drawings.

B During the placement of the protective cover soil material, no construction equipment shall be allowed directly on the liner or drainage net. Any damage to these components shall be repaired immediately in accordance with the specifications. A minimum 4-foot-thick traffic surface shall be constructed over the liner to support haul trucks.

C Care shall be taken to protect the liner. Sand ramps (4-foot thick) shall be provided on slope locations used for entry and exit and otherwise as necessary (heavy traffic areas, etc.). Only large radius turns by loader and other equipment shall be permitted; sharp turns may damage the liner.

D A low-ground-pressure dozer (6 psi maximum contact pressure) shall be used for spreading and grading of the protective cover soil layer.

E Protective cover soil shall be placed on the side slopes starting at the toe of the slope and working toward the top of the slope.

F Protective cover soil layer material can only be spread when the liner is taut or stretched evenly over the base of the landfill. The protective cover soil layer material shall not be spread when the liner is elongated due to higher daytime temperatures and exposure to sun. The CONTRACTOR must make provisions to cover the liner under non-elongated conditions.

G The final grade shall be laid to elevations as shown on the Drawings.

H No protective cover soil material shall be placed or spread while the ground or protective cover soil material is frozen or thawing or during freezing or heavy wet weather conditions. The sand surface shall be made smooth and free from ruts or indentation at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area.

I Protective cover materials shall not be installed when and if the materials are saturated or not suitable for supporting equipment.

J If areas for piping are first covered where shown on the Drawings, trenches for leachate collection pipes shall be excavated through the protective cover soil material. The CONTRACTOR shall exercise special care not to disturb or damage the fabric cushion, drainage net or liner. If a backhoe is used to construct the trench, a blade modification (i.e. rubber) section shall be installed on the bucket to protect the liner. Any liner damage shall be immediately repaired as directed by the ENGINEER at no additional cost to the Owner.

K A 2-in minimum layer of protective cover soil material shall be maintained in the bottom of the trench followed by pipe. Locations for leachate piping (and fabric cushion) shall be survey located and installed to the lines shown on the Drawings, and shall be backfilled with SCDOT No. 67 Stone to the depth and width shown on the Drawings. Care shall be taken during backfilling of the pipe to assure the pipe will not be crushed or otherwise damaged or shifted.

L Following placement of the SCDOT No. 67 Stone, the trench or design location, shall be backfilled with SCDOT No. 789 Stone to the depth and width shown on the Drawings.

M Following placement of the SCDOT No.789, the C-33 sand shall be placed to the dimensions indicated on the drawings.

N Following construction of the leachate piping, the protective cover soil material shall be brought to final grade and compacted as specified herein.

O Alternate installation plans may be submitted as referred to in 1.03.A.3 and .4 of the Section and implemented with prior approval by the CQA Officer.

3.02 FIELD QUALITY CONTROL

A. CQA Plan: Inspection/testing will be a joint effort between the CONTRACTOR and the OWNER.

B. Testing and Inspection Services: OWNER shall employ a CQA Officer and Quality Assurance Laboratory to perform soils observation and testing services for quality assurance of the protective cover layer. CONTRACTOR shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of the protective cover layer. CONTRACTOR shall factor this quality assurance verification and testing and quality control testing into its schedule and sequence of operations.

C. Coordination: CONTRACTOR shall be responsible for coordination of field services with the CONTRACTOR's CQC Officer, Quality Control Laboratory, and with the OWNER's CQA Officer.

D. Initial Observation: Protective cover layer placement operations shall be performed after the surface has been properly prepared and has been observed and approved by CQA Officer. No protective cover layer materials shall be placed unless the CQA Officer approves the operation. Any fills placed without CQA Officer's observation and prior approval shall be removed in a manner to avoid damage or disturbance to the existing approved work, and the excavation shall be filled as specified herein, at no additional cost to OWNER.

E. Field Control: The minimum testing frequencies for field tests to be performed by the CONTRACTOR's Quality Control personnel are provided in the Table 4

TABLE 4

TEST	METHOD	FREQUENCY	
		CQC	CQA
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	2/acre	none
Moisture Content[1]	ASTM D2216 ASTM D3017 ASTM D1556	2/acre	none

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

F. Any sample or area tested shall be rejected, removed and replaced or otherwise corrected if it does not meet the requirements of the technical specifications. Re-constructed areas shall have feathered, overlapping edges that tie into adjacent fill material.

3.03 REPORTING

A The Contractor's CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work, as associated with Protective Cover was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of South Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and documentation of reworked areas with passing tests, as appropriate.

END OF SECTION

SECTION 02701

DRAINAGE AND EROSION LAYER

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to install the Drainage Layer and Erosion Layer as shown on the Drawings and as specified herein. Associated work includes borrow source excavation, hauling, placement, compaction, grading and quality control testing of Drainage Layer and Erosion Layer.

1.02 RELATED WORK

A. Section 01050: Field Engineering

B. Section 02200: Excavation, Backfill, and Compaction

C. Section 02280: Infiltration Layer

D. Section 02776: Textured LLDPE Liner

1.03 SUBMITTALS

A. The CONTRACTOR shall furnish representative samples of proposed Drainage Layer and Erosion Layer soils, each weighing approximately 75 pounds to the CQA OFFICER for approval at least 14 calendar days prior to the date of anticipated use of such material.

B. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

1.04 REFERENCE STANDARDS

A. ASTM - American Society for Testing and Materials:

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6 . ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

10. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

12. ASTM D5268 - Standard Specifications for Topsoil Used for Landscaping Purposes

13. ASTM D2974 - Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A. The quality assurance and quality control consists of laboratory conformance testing of samples supplied from each soil source and testing during installation.

B. Conformance testing requirements are specified in Paragraph 1.07

1.06 PROTECTION

A. The CONTRACTOR is solely responsible for protection of the work. Completed work that is damaged by weather or other means shall be repaired by the CONTRACTOR at no additional cost to the OWNER.

1.07 SOIL TESTING

A. Prior to the placement of the Drainage Layer and Erosion Layer and during such placement, the CQA Officer shall select areas within the limits of the work for testing. The CONTRACTOR shall cooperate fully in obtaining the information desired.

B. The CONTRACTOR'S CQC Officer shall perform the following laboratory soil testing in accordance with the standards listed in paragraph 1.04.

1. Perform particle size distribution test (ASTM D422), Atterberg limits (ASTM D4318), and Standard Proctor compaction test (5 point curve, ASTM D 698) for each soil type proposed for use as Drainage Layer and Erosion Layer soils and for every 20,000 cubic yards (or change in material) of Drainage Layer and Erosion Layer soil used. Three Organic Content (loss on ignition, ASTM D2974) tests shall be performed for soil to be used in the top 6 inches.

C. The in-place density and moisture content of the Drainage Layer and Erosion Layer soil shall be measured by the CQC Officer. At minimum, the testing frequency shall be 1 test per 2-acres per lift of fill (or 1 test per lift of fill if the area being worked is less than 2-acres in size).

D. Erosion Layer Analysis:

a. The CONTRACTIOR shall perform and furnish soil analysis made by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil.

b. Report suitability of Erosion Layer for lawn growth.

c. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce a satisfactory growth layer.

1.08 DELIVERY, STORAGE AND HANDLING

A. Materials shall be stockpiled at designated areas within the limits of construction approved by the Owner. At the end of each day, the material will be smooth rolled and sloped to minimize erosional impact on the stockpile. Removal of stockpile material shall be done in a manner to minimize intrusion of soils adjacent to and beneath the stockpile.

PART 2: PRODUCTS

2.01 MATERIALS

A. Materials for use as Drainage Layer and Erosion Layer soils shall be as described below. The CONTRACTOR shall notify the CQA Officer of the source of each material. Materials shall be furnished as required from approved off-site or on-site sources and hauled to the site.

B. The soil used to construct the Drainage Layer and Erosion Layer shall be capable of maintaining vegetation and conform to the following criteria.

a. The soil shall have 100% passing the 3-inch sieve.

b. At least 80% shall pass the #4 sieve; at least 15% shall pass the # 200 sieve.

c. The organic content shall be at least 4% (upper 6" only).

d. Maximum Liquid Limit is 50%

e. Maximum Plasticity Index is 25%

f. pH range of 5.5 to 7

g. free of extraneous materials harmful to plant growth

h. Internal Friction Angles no less than 22.5°, as determined by ASTM D4767

i. Maximum Permeability of 4×10^{-4} cm/s (Drainage Layer only, or portion of Drainage Layer thereof as approved by the Engineer; re-compacted to 93% of the material's maximum dry density and optimum moisture content)

2.02 SOIL AMENDMENTS

A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 (2.36 mm) sieve and a minimum 75 percent passing a No. 60 (250 micrometer) sieve.

1. Provide lime in the form of dolomitic limestone.

B. Aluminum Sulfate: Commercial grade, unadulterated.

C. Sand: Clean, washed, natural or manufactured sand, free of toxic materials.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat.

F. Sawdust or Ground-Bark Humus: Decomposed, nitrogen-treated, of uniform texture, free of chips, stones, sticks, soil, or toxic materials.

1. When site treated, mix with at least 0.15 lb of ammonium nitrate or 0.25 lb of ammonium sulfate per cu. ft. of loose sawdust or ground bark.

G. Manure: Well-rotted, unleached stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

H. Herbicides: EPA registered and approved, of type recommended by manufacturer.

I. Water: from approved source

PART 3: EXECUTION

3.01 DRAINAGE LAYER AND EROSION LAYER PLACEMENT

A. Placement of the Drainage Layer shall not start until the Flexible Membrane Liner and Geocomposite Drainage Net is accepted by the CQA Officer and all required testing is completed and accepted by the CQA Officer.

B. During the placement of the Drainage Layer and Erosion Layer soil material, no construction equipment shall be allowed directly on the liner or drainage net. Any damage to these components shall be repaired immediately in accordance with the specifications. A 3.5-foot-thick traffic surface shall be constructed over the liner to support haul trucks and other non-low ground pressure equipment. A minimum 1.5-foot-thick layer of Drainage Layer and Erosion Layer material shall be maintained for low ground pressure equipment. No equipment will be allowed on Drainage Layer and Erosion Layer that is less than 1.5 feet in thickness. Soil for the Drainage Layer and Erosion Layer shall be compacted to at least 93% of its maximum dry density as determined by ASTM D698.

C. Care shall be taken to protect the liner. Sand ramps shall be provided on slope locations used for entry and exit and in other heavily traveled areas. Only large radius turns by equipment shall be permitted as sharp turns may damage the liner.

D. Only low-ground-pressure equipment (6 psi maximum contact pressure) shall be used for spreading and grading of the Drainage Layer and Erosion Layer.

E. Drainage Layer and Erosion Layer soil shall be placed on the side slopes starting at the toe of the slope and working toward the top of the slope.

F. Drainage Layer and Erosion Layer material can only be spread when the liner is taut or stretched evenly over the base of the landfill. The Drainage Layer and Erosion Layer soil layer material shall not be spread when the liner is elongated due to higher daytime temperatures and exposure to sun. The CONTRACTOR must make provisions to cover the liner under non-elongated conditions.

G. The surfaces of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the grading plan and no soft spots or un-compacted areas will be allowed in the work.

H. No compacting shall be done when the material is too wet either from precipitation, surface water runoff, or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction.

I. Water For Compaction

1. The CONTRACTOR shall utilize water as required to guarantee constructability and protection of the in-place and stored soil.

2. The CONTRACTOR shall provide water from an OWNER approved source.

3. The water shall be of suitable quality approved by the CQA Officer.

J. During construction, the CONTRACTOR shall make all necessary provisions to deal with inclement weather conditions. The CONTRACTOR shall be fully responsible for control of storm water during installation of the Drainage Layer and Erosion Layer.

K. No material shall be placed, spread, or compacted while the ground or the soil material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The Drainage Layer and Erosion Layer surfaces must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the material. Any re-grading due to the above conditions or final preparation shall require retesting at those locations for thickness and density and shall be at the cost of the CONTRACTOR.

L. Prior to seeding and mulching the CONTRACTOR shall scarify the finished surface of the Erosion Layer to a depth of 3 inches. The surface shall be mechanically or hand raked to remove any loose roots or rocks.

3.02 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. The field quality control and quality assurance test shall be conducted in accordance with Paragraph 1.07.

B. Re-constructed areas shall have feathered, overlapping edges that tie into adjacent liner subgrade areas.

C. The CONTRACTOR shall submit a survey plan with final elevation of top of Drainage Layer and Erosion Layer for CQA Officer's approval in accordance with Section 01050.

3.03 DISPOSAL OF SURPLUS MATERIAL

A. No excavated materials shall be removed from the site of the work or disposed of by the CONTRACTOR except as specified by the CQA Officer. Materials shall be neatly piled on-site at locations directed by the OWNER so as not to inconvenience the public and adjoining property owners until used or otherwise disposed of as specified below.

B. Surplus Drainage Layer and Erosion Layer soil shall become the property of the OWNER and be stockpiled as directed by the OWNER.

3.12 GRADING

A. Grading shall be performed at all places that are indicated on the Drawings, to the lines, grades and elevations shown and otherwise as directed by the ENGINEER. During the process of grading, the subgrade shall be maintained in such condition that it will be well drained at all times. When directed, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the performance or condition of the work.

B. If at the time of grading it is not possible to place material in its final location, it shall be stockpiled for later use in areas approved by the CQA Officer. Stockpiled material shall be smooth rolled at the end of each day to promote runoff of stormwater. No extra payment will be made for the stockpiling or double handling of excavated material.

C. The ENGINEER reserves the right to make minor adjustments or revisions in lines or grades if found necessary as the work progresses, in order to obtain satisfactory construction.

END OF SECTION

SECTION 02776

TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to manufacture, supply and install Textured High Density Polyethylene (HDPE) liner as shown on the Drawings and as specified herein. This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured.

1.02 RELATED WORK

A Section 02275: Compacted Soil Liner

B Section 02274: Geocomposite Drainage Net

C Section 02700: Protective Cover

D Section 002985: Geomembrane Leak Location Survey

1.03 SUBMITTALS

A At least 60 calendar days prior to HDPE liner installation, submit the following information in accordance with Section 01340:

1. Submittals relating to liner manufacturer and liner

   a. Corporate Background

   b. Manufacturing capabilities:

      (1) Information on factory size, equipment, personnel, number of shifts per day and production capacity per shift.

      (2) List of material properties and samples of liner with attached certified test results.

      (3) Manufacturer's quality control program and manual including description of laboratory facilities.

      (4) A list of ten completed facilities totaling a minimum of three million square feet, for which the manufacturer has manufactured a textured HDPE liner. The following information shall be provided for each facility.

         # Name and purpose of facility, its location and date of installation

- # Name of Owner, project manager, design engineer and installer.
- # Liner thickness and surface area
- # Information on performance of the facility

c. The origin of the resin to be used in the manufacturing of liner including the supplier's name and production plant, as well as brand name and number.

d. A fingerprint of the manufacturer's resin properties as listed in Appendix A, Table A1. The purpose of these tests is to identify the manufacturer's liner product. The results of these tests shall be submitted to the Engineer for approval of the product. Once the product is approved, all HDPE liner to be supplied for the Project shall be manufactured using the same resin type identified through fingerprinting tests.

e. Certification that all resin used in the manufacture of textured HDPE liner for this Project meets the approved fingerprinting protocol.

f. Copy of quality control certificates in conformance with Paragraphs 2.01 and 2.02.

g. Certification that the textured HDPE liner and extrudate produced for this project has the same properties.

2. Submittals relating to installation Contractor

a. Background Information

b. Installation capabilities:

(1) Information on equipment (including tensiometer certification) and personnel.

(2) Anticipated average daily production (Complete including QC measures).

(3) A minimum of three field seam samples and a list of minimum values for seam properties.

c. A list of five completed facilities totaling two million square feet for which the installer has installed textured HDPE liner. The following information shall be provided for each facility:

(1) Name and purpose of facility, its location and date of installation.

(2) Name of Owner, design engineer, manufacturer and name and telephone number of contact at the facility who can discuss the project.

(3) Thickness of liner and surface area of the installed liner.

(4) Type of seaming, patching and tacking equipment.

(5) A copy of the manufacturer's certification or approval letter.

(6) And, prior to installation, provide resume(s) of the qualifications of the Installation Supervisor and Master Seamer, and Quality Control personnel to be assigned to this project.

d. Shop drawings, including:

(1) Proposed panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings.

(2) Details of seaming the liner, anchoring, connections, penetrations and other construction details.

e. Installation schedule

f. A quality control manual that specifically defines the quality assurance program during installation. The manual shall include daily procedures, welding techniques, field testing procedures, lab testing procedures, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and all other information necessary to ensure a high quality liner installation.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D792 – Specific Standard Test Method for Tensile Properties of Plastics by Displacement.

2. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

3. ASTM D751 - Standard Test Methods for Testing Coated Fabrics.

4. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

5. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

6. ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.

7. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

8. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

9. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

10. ASTM D5397 – Procedure to perform single point notched constant tneil load – Appendix (SP-NCTL)

11. ASTM D1898 – Sampling of Plastics

12. ASTM D4833 – Index puncture resistance of geotextiles, gemembranes and related products

13. ASTM D5596 – Test method for microscopic evaluation of the dispersion of carbon black in polyolefin geosynthetics

14. ASTM D3895 - Standard Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.

15. ASTM D4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

16. ASTM D7466 – Test method for measuring the asperity height of textured geomembranes

17. GRI Test Method GM13 - Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

18. GRI Test Method GM19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

D Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A Quality Assurance activities are performed to provide assurance that the materials were constructed as specified in the contract specifications and may include manufacturing facility inspections, verifications, audits and evaluation of raw materials and geosynthetic products to assess the quality of the manufactured materials.

B In addition to manufacturer and installer requirements for qualifications and certification specified in Paragraph 1.03, the Quality Assurance Plan consists of conformance testing of the material manufactured for the project and delivered to the site, and field quality control during installation.

C Conformance testing requirements are specified in Paragraph 2.03. The purpose of conformance testing is to assure that the supplied material is constructed as specified in the contract specifications and to the manufacturer's quality control certificates.

D Field quality control requirements are specified in Paragraph 3.06. The purpose of field quality control procedures is to assure that the liner has been installed in accordance with the specifications and manufacturer's recommendations.

E Quality Control Plan

1. The forms in Appendix C for liner quality control documentation shall be used for field installation documentation. Alternative forms, which provide the same level of detail, may be used for documentation as approved by the Engineer.

F Geomembrane Quality Control Documentation

1. Pre-deployment Conference

a. Prior to commencing work, a pre-deployment conference shall be held and the following project personnel shall be identified by name and recorded in the project files:

Contractor
Contractor's Representative
CQA Engineer
Resident Project Representative (RPR)
Installation Supervisor / Quality Control Personnel
Installer
CQC Personnel

b. Two duplicate project files shall be maintained. One shall be maintained by the CQA Representative or Resident Project Representative (RPR) and the other shall be maintained by the Installation Supervisor. At the end of each work week the files shall be updated and checked to assure that copies of all pertinent project information is included in each file.

c. Blank copies of the following nine project forms shall be available on-site throughout the duration of the project:

Form No.	Title
100	Liner Project QC Log
101	Subgrade Surface Acceptance
102	Receiving QC Log
103	Personnel QC Log
104	Daily Panel Placement Log
105	Daily Seaming QC Log
106	Daily QC Report Pre-Weld Testing
107	Daily QC Report Earthen Cover

G Record Drawings

1. The Contractor shall furnish record drawings showing changes, if any, from the approved installation drawings which are to include all destructive sample locations (if performed), any patches used to repair liner defects, all panels and

panel seams and patch identifications assigned in the field; and a copy of complete documentation for final installation of the liner.

1.06 QUALIFICATIONS

A Manufacturer

1. The manufacturer of the lining material described hereunder shall have previously demonstrated their capability to produce this liner by having at least ten years continuous experience in the manufacture of textured HDPE liner and successfully manufactured a minimum of 50 million square feet of similar liner material for hydraulic lining installations.

B Installer

The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's liner. Installation shall be performed under the constant direction of a single installation supervisor who shall remain on site and be in responsible charge, through the liner installation, for liner layout, seaming, patching, testing, repairs and all other activities required by the installer. The installation supervisor shall have installed or supervised the installation and seaming of a minimum of two million square feet of textured HDPE liner. The Installation contractor must be a manufacturer' approved installer for the product.

1.07 PACKAGING, DELIVERY, STORAGE AND HANDLING

A The geomembrane shall be rolled onto a substantial core held firm by dedicated straps, slings or other suitable means approved by the Engineer. The liner rolls shall be packaged and shipped by appropriate means to prevent damage of the liner rolls. Off-loading and storage of the liner is the responsibility of the Contractor. The liner rolls shall be unloaded in the presence of the CQA Officer or his designated CQA representative. The Contractor shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.

B Damage during off-loading shall be documented by the CQA Officer or CQA representative. Any damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined by the Engineer.

C The liner rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions and excessive heat that may damage the liner material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

1.08 MATERIAL WARRANTY

A A warranty for the textured HDPE liner manufacturer shall be provided by the manufacturer. It shall include on a pro-rated basis, warranty against manufacturing defects and material degradation under outdoor exposure for a period of five years from the date of installation. The manufacturer shall replace at no expense, any material which fails from the above causes within the warranty period. The

manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the textured HDPE liner against defects in installation and workmanship for the period of two years commencing with the date of final acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

1.10 DEFINITIONS AND RESPONSIBILITIES

A Contractor

1. The Contractor is the firm or corporation with whom the Owner has entered into agreement to construct the project. The Contractor is responsible for scheduling and coordination of the required work with the Engineer, manufacturer and the installer to complete the project. The Contractor is responsible for furnishing as built drawings and a copy of the complete documentation of the liner system. The Contractor is also responsible for daily updating of the design drawings onsite and for any and all deviations from these drawings. The Contractor is responsible for all submittals by the manufacturer and installer as required by the Specifications.

B Manufacturer

1. The manufacturer is the firm or corporation responsible for production of the liner material to be used in the project. The manufacturer shall produce a consistent product meeting the project specifications, and shall provide quality control documentation for the product specified herein. A Manufacturer's Certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results shall be furnished prior to shipment.

C Installer

1. The installer is the firm responsible for installation of the liner. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's geomembrane. The Installer shall be responsible for field handling, storing, placing, seaming, field testing and all other aspects of the liner installation.

PART 2: PRODUCTS

2.01 MATERIALS

A General

1. The liner shall be manufactured of new, prime first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and chemically resistant to leachate.

2. The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. The Engineer may reject all or portions of units (rolls) of geomembrane if significant quantities of production flaws are observed.

3. The sheets shall be manufactured to a minimum 22-ft seamless width. Labels on each roll shall be legible and identify the information listed in Part 2.02, A.4

4. The textured sheet must not delaminate during tensile testing (i.e., textured layers and "particles" of texture must not separate). It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

B Properties

1. The geomembrane liner rolls shall meet the minimum properties listed in Appendix B, Table B1.

C Other Materials

1. Extrudate welding rods shall be of the same compound as the liner and supplied by the manufacturer and shall be delivered in original sealed containers. Each container shall have a label bearing the brand name, manufacturer's lot number and complete directions as to proper storage. Manufacturer shall provide welding rod in an adequate quantity to complete the project.

2. When applicable, Nominal 40-mil flexible membrane liner (FML) leachate collection stone rain cover shall have minimum properties required by GRI Test Method GM13 (latest revision).

2.02 QUALITY CONTROL DOCUMENTATION

A Prior to shipment and installation of any liner material, the Manufacturer shall provide the following information certified by the manufacturer for the delivered liner.

1. Origin, identification and production of the resin (supplier's name, brand name and production plant).

2. Copies of quality control certificates issued by the resin supplier.

3. Each roll delivered to the project site shall have the following identification information:

a) Serial number
b) Lot number
c) Roll number
d) Resin type
e) Roll length
f) Material width
g) Weight
h) Thickness
i) Inspection identification

4. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, frequency, and test results. At a minimum the following test results shall be provided in accordance with test requirements specified in Appendix B:

   # Thickness
   # Density
   # Tensile properties
   # Tear resistance
   # Carbon black content
   # Carbon black dispersion

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. Engineer shall obtain samples from the delivered material, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Manufacturer shall pay for conformance testing on the initial roll at the Manufacturer's expense. The Engineer shall obtain the samples from the roll, and mark the machine direction and identification number. The following conformance tests shall be conducted at the laboratory:

   # Thickness
   # Density
   # Tensile properties
   # Tear resistance
   # Carbon black content
   # Carbon Black Dispersion

B These conformance tests shall be performed in accordance with Appendix B. All costs for the initial conformance testing will be paid by the Owner.

C All conformance test results shall be reviewed by Engineer and accepted or rejected, prior to the delivery and placement of the liner. All test results shall meet, or exceed, the property values listed in Appendix B. In case of failing test results, the manufacturer may request that another sample be retested by the independent laboratory with manufacturer's technical representative present during the testing procedures. This retesting shall be paid for by the manufacturer. The manufacturer may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted. If both laboratories do not report passing results, all liner material from the lot representing the failing sample will be considered out of specification and rejected.

PART 3: EXECUTION

3.01 COMPACTED SOIL LINER PREPARATION

A Preparation of the compacted soil liner surface shall be as specified in Section 02275.

B The surface of the compacted soil liner shall be smooth, uniform, and free from sudden changes in grade (such as vehicular ruts), rocks, stones, debris and deleterious materials. The moisture content of the compacted soil liner must be maintained within the project specifications until the synthetic liner has been installed. If excessive drying occurs, the contractor shall re-hydrate and compact the affected area to the Engineer's satisfaction. During actual placing and seaming of the liner, the compacted soil liner surface shall be kept free of all standing water. If the compacted soil liner surface below the liner becomes wet and unstable, it shall be dried and re-compacted to the Engineer's satisfaction. If drying and re-compacting the material is insufficient, the unstable material must be removed and replace with approved material

C Prior to liner installation, the Contractor and installer shall verify in writing and submit to the CQA Officer:

1. Lines and grades are in conformance with the Drawings and Specifications.

2. The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

D The Contractor shall not proceed with liner installation until a complete report on the compacted soil liner thickness and hydraulic conductivity tests has been submitted and approved by the CQA Officer.

3.02 ANCHOR TRENCH

A The anchor trench shall be constructed as shown on the Drawings and as specified herein.

B Slightly rounded corners shall be provided in the trench to avoid sharp bends in the liner.

C The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with local fill material and compacted to 92 percent standard proctor density, ASTM D698 as specified in Section 02200.

D If the anchor trench is located in a clayey material susceptible to desiccation, the amount of trench open at any time shall be limited to one day of liner installation capacity.

3.03 LINER PLACEMENT

A Weather Conditions

1. Liner placement shall not proceed at an ambient temperature below 40 degrees F or above 104 degrees F unless otherwise authorized, in writing, by the CQA Officer or his/her field representative. Liner placement shall not be performed

during precipitation, excessive moisture, in an area of ponded water, or excessive winds.

B Method of Placement

1. Each Liner panel shall be layed out in accordance with the approved shop drawings prepared by the Manufacturer. The layout shall be designed to keep field joining of the textured HDPE liner to a minimum and consistent with proper methods of textured HDPE liner installation.

2. Each liner panel shall be identified by panel number, roll number and date of deployment. The liner panel number shall be placed on the ends of each panel and in the middle.

3. For liner placed on 4 to 1 or steeper slopes, the seams shall be oriented in the direction of the slope. Horizontal seams on 4 to 1 slopes or steeper shall not be allowed except for cases in which it is unavoidable. In these instances, a cap strip shall be placed over the seam.

4. The equipment used to deploy the liner shall not cause rutting of the compacted soil liner surface. If rutting occurs, the Contractor shall suspend all liner placement activities and repair the ruts and immediately employ an alternative method for liner deployment. Liner rolls shall be placed using spreader and rolling bars with cloth slings. If a sheet must be relocated a distance greater than its width, a slip sheet shall be used.

5. The RPR shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Officer.

6. The installer shall not drag the liner panels over the compacted soil liner.

7. All liner shall be anchored as shown on the Drawings and consistent with manufacturer's recommendations. Sufficient liner shall be installed within the anchor trench to ensure proper installation prior to backfilling the trench.

8. Personnel working on the liner shall not smoke, wear damaging shoes or involve themselves in any activity that may damage the liner.

9. The liner shall be properly weighted with sand bags to avoid uplift due to wind.

10. Vehicular traffic across the liner shall not be allowed.

11. All damage shall be recorded and located on the record drawings.

12. When tying into existing liner, all excavation of previously installed liner shall be performed by hand to prevent damage.

13. The liner shall be kept free of debris, unnecessary tools and materials. In general, the liner area shall remain uncluttered in appearance. Any generators in use while on the liner shall have "drop" sheets place underneath.

14. Fuel shall not be stored on the liner.

15. To prevent a "trampoline effect" from forming, the Contractor shall place sufficient sand bags on the liner along the toe of slopes to ensure full contact of the geomembrane liner with the compacted soil liner surface. In addition, the horizontal seams nearest the toe of slope shall remain unwelded until all other seams in the area are completed. The final seam shall be welded when the liner is cool and fully contracted. Care shall be taken to ensure that the liner contacts the subgrade in all locations before completing the seam.

3.04 FIELD SEAMS

A Individual panels of liner shall be laid out and overlapped by a minimum of 4-in prior to welding. The area to be welded shall be cleaned and prepared in accordance with the installer's quality control welding procedures.

B Double track hot wedge fusion welder shall be used for straight welds.

C Extrusion welder shall be used for cross seam tees, patches, repairs, penetration boots and detailed work.

D The welding equipment used shall be capable of continuously monitoring and controlling the temperature speed, and pressure in the zone of contact where the machine is actually fusing the liner material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

E No "fish mouths" will be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped and a patch fusion weld shall be applied. All welds upon completion of the work shall be tightly bonded. Any liner area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of liner. The number of patches per 100-ft length shall not exceed five. If more than five patches per 100-ft length are necessary, then the entire 100-ft length of seam shall be removed. Further welding will cease at this time and the CQA Officer shall be notified.

F All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be welded together.

G All fusion welded "T" seams (i.e., the result of the liner panels placed perpendicular to each other) shall be double welded where possible. The extrusion process shall be used for the second weld.

H All extrudate shall be free of dirt, dry and protected from damage.

I If an extrusion welder is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extradite shall be placed on a sacrificial sheet and disposed of.

J All seams constructed on sloped surfaces shall be vertical seams. Where horizontal seams can't be avoided (due to compounded slopes) on sideslope surfaces, a 18" wide cap strip of the same synthetic material shall be placed on top of the horizontal seam and welded to the adjacent panels to provide additional structural integrity. All cap strip seams shall be non-destructively tested.

K All vertical panels placed on sloped surfaces shall extend 5-ft inward from the toe of slope or edge of trench.

L All end seams shall be staggered a minimum of 5-ft in length between contiguous panels.

M To prevent moisture buildup during fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of liner that is to be seamed.

N If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

O All seams shall extend to the full extent into the anchor trench.

P All factory seams, field seams and repair welds shall meet seam strength requirements specified in Appendix B, Table B2.

3.05 SEAMING WEATHER CONDITIONS

A Normal Weather Conditions

1. The normal required weather conditions for seaming are:

   a. Ambient temperature higher than 40 degrees F and lower than 104 degrees F.

   b. No precipitation or other excessive moisture, such as fog or dew.

   c. No excessive winds.

2. These weather conditions shall be fulfilled during seaming process.

B Cold Weather Conditions

1. If the ambient temperature is below 40 degrees F, the following conditions shall be met to ensure quality seaming process:

   a. Preheating the surface of the liner to achieve normal temperature range.

b. Preheating may be waived by the CQA Officer or the RPR if the installer demonstrates that satisfactory welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

c. Preheating devices shall be approved by the manufacturer.

d. Care shall be taken to assure that surface temperatures are not lowered below the minimum required surface temperature for welding due to winds.

e. Additional destructive tests samples shall be taken at the discretion of the CQA Officer.

f. Test seams, as described in Paragraph 3.06A, shall be performed under the same ambient temperature conditions as the actual seams.

C Warm Weather Conditions

1. If the ambient temperature is above 104 degrees F, no seaming of liner shall be permitted unless the installer can demonstrate to the satisfaction of the Engineer that liner seam quality is not adversely impacted.

2. Test seams shall be performed under the same ambient temperature conditions as the actual seams.

3. Additional destructive tests shall be taken at the discretion of the CQA Officer.

3.06 FIELD QUALITY CONTROL

A Pre-Weld Testing

1. A test weld 3-ft long from each welding machine shall be run upon the beginning of each shift and every four hours thereafter, under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature and welder's name, temperature and speed, welding machine number. A tensiometer shall be required to be on-site before and during liner installation for the purpose of testing samples. Six specimens of welds 1-in wide shall be cut from the test weld and tested on site with the presence of the RPR for shear and peel strength (3 each) in accordance with Appendix B, Table B-2. No welder may start work until the sample weld has been approved by the RPR.

2. Test seams shall be performed under the same conditions as the actual seams and shall be at least 3-ft long, 1-ft wide after seaming. Test seam for welding shall be cut out of the liner rolls.

B Non-destructive Seam Testing

1. The installer shall perform nondestructive test on all field seams over their full length. The purpose of this test is to assure continuity and integrity of the seams. Vacuum and air pressure tests shall be used for nondestructive testing. The vacuum test shall be used for extrusion welds and single track hot wedge welds. The air pressure test shall be used for double track hot wedge welds.

The CQA Officer at any time during the installation believes the seaming process may not be performing adequately, it may, to avoid destructive sampling of the actual liner system, request additional test seams. This shall be done by the Installer at no additional cost to the Owner.

2. Vacuum Testing

a. Equipment for testing single wedge fusion seams and extrusion seams shall be comprised of the following:

(1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gage.

(2) A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

(3) A rubber pressure/vacuum hose with fittings and connections.

(4) A plastic bucket and wide paint brush.

(5) A soapy solution.

b. The following procedures shall be followed by the installer:

(1) Excess sheet overlap shall be trimmed away.

(2) Clean the window, gasket surfaces and check for leaks.

(3) Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.

(4) Wet a strip of liner approximately 12-in by 48-in (length of box) with the soapy solution.

(5) Place the box over the wetted area and compress.

(6) Close the bleed valve and open the vacuum valve.

(7) Ensure that a leak-tight seal is created.

(8) For a minimum period of ten seconds, examine the liner through the viewing window for the presence of soap bubbles.

(9) If no bubbles appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 3-in overlap and repeat the process.

10) All areas where soap bubbles appear shall be marked and repaired in accordance with Paragraph 3.07G and then retested.

11) All test locations which have passed vacuum testing shall be marked with the test date and individual performing the test.

c. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the RPR for uniformity and completeness.

3. Air Pressure Testing.

a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.

b. Equipment for testing double fusion seams shall be comprised of the following:

(1) An air pump equipped with pressure gage capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the liner.

(2) A manometer equipped with a sharp hollow needle, or other approved pressure feed device.

c. The following procedures shall be followed by the installer.

(1) Seal both ends of the seam to be tested.

(2) Insert needle or other approved pressure feed device into the tunnel created by the double wedge fusion weld.

(3) Energize the air pump to a pressure between 27 and 40 psi, close valve and sustain pressure for at least five minutes.

(4) If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair in accordance with Paragraph 3.07G and retest.

(5) If the faulty area cannot be isolated and repaired, the length of seam which can not be tested shall be capped with liner strip, extrusion welded and vacuum tested. The seam shall be documented as a failed seam indicating the corrective measure.

(6) If loss of pressure is 3 psi or less, release air pressure at the opposite end of where the pressure is applied to verify that the full seam was pressurized and that there was no blockage in the air channel.

(7) Remove needle or other approved pressure feed device and seal.

(8) All test locations which have passed air pressure testing shall be marked with the test date and individual performing the test.

C Destructive Seam Testing

1. At the discretion of the CQA Engineer and/or RPR, destructive seam testing shall be performed on samples of the installed liner.

   a. At any given sampling location, two types of samples shall be taken by the Installer at the request of the CQA Engineer and/or RPR.

   b. First, two specimens for field testing shall be taken. Each of these specimens will be 12 in. by 12 in. long (minimum), with the seam centered parallel to the width. If both specimens pass on-site field test for peel and shear in accordance with Appendix B, Table B-2, a sample for laboratory testing may be taken.

   c. The sample for laboratory testing shall be located between the two specimens for the peel and shear field testing. The destructive sample will be 12 in. wide by 42 in. long of the liner Installer requests a sample; otherwise, the destructive sample will be 30 inches with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

      - One portion to the Installer for laboratory testing, if so requested, 12 in. x 12 in.;
      - One portion to the Owner for archive storage, 12 in. x 12 in.; and
      - One portion for CQA Laboratory testing, 12 in. x 18 in.

   d. Destructive testing will include peel and shear testing. At least 5 specimens will be tested for each test method. A maximum of one non-FTB (Film Tear Bond) failure is acceptable provided that strength requirements are met on that sample.

   e. The following procedures apply whenever a sample fails a destructive test, weather that test is conducted by the CQA Laboratory, the Installers laboratory, or by field tensiometer. The Installer has two options:

      (1) The Installer can reconstruct the seam between any two passed destructive seam test locations, or

      (2) The Installer can trace the seaming path to an intermediate location (at least 10 ft from the point of the failed test in each location) and take a small sample for an additional field test at each location. If these additional samples pass the field tensiometer testing, then full destructive laboratory samples are taken. If these destructive laboratory samples pass the tests, then the seam is reconstructed between these locations by capping for extrusion or fusion welds, at the direction of the Engineer. If either the field tensiometer or the laboratory sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

3.07 ELECTRIC CONDUCTIVITY TESTING

Following installation of the drainage layer, electric conductivity testing may be performed to ensure no puncturing of the liner occurred during installation. The Contractor will fully cooperate with the testing including providing survey service and laborers to establish testing points and vacating areas designated by the testers. The laborers will also perform excavation of sand and removal of fabric at locations of investigation. Repair of damaged liner and replacement of fabric and sand will be performed by the contractor at no additional cost to the Owner.

3.08 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

APPENDIX A

TABLE A1

PROPERTIES and TEST METHODS FOR TEXTURED HIGH DENSITY

POLYETHYLENE (textured HDPE) LINER

PROPERTY	TEST METHOD
Density	ASTM D792 or ASTM D1505
Melt Index	ASTM D1238
Carbon Black Content	ASTM D1603
Oxidative Induction Time	ASTM 3895

The above tests shall be performed by the manufacturer of the textured HDPE liner for identification of the manufacturer's product. The above test results shall be submitted to the Engineer for approval of the product. Properties shall meet listed test values of GRI-GM13 or its latest version.

APPENDIX B

This page intentionally left blank.

TABLE B1

MATERIAL PROPERTIES
TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

PROPERTY	UNIT	LIMIT	TEST METHOD	VALUE
Thickness[1]	mils	minimum	ASTM D5994	60
Density	g/cc	minimum	ASTM D1505, or ASTM D792	0.940
Tensile Properties (Each Direction)			ASTM D6693	
- Yield Strength	(lb/in)	min. ave.		126
- Break Strength	(lb/in)	min. ave.		90
- Elongation at Yield	(%)	min. ave.		12
- Elongation at Break	(%)	min. ave.		100
Tear Resistance	(lb)	min. ave.	ASTM D1004	42
Puncture Resistance	(lb)	min. ave.	ASTM D4833	90
Carbon Black Content	(%)	range	ASTM D1603, or ASTM D4218	2.0 to 3.0

Notes referring to Table B1:

1. Value represents lowest individual value

TABLE B2

FACTORY AND FIELD SEAMS PROPERTIES
TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

Property (ASTM D6392)	Units	Value
Hot Wedge Seams [1]		
- shear strength [2]	lb/in	120
- shear elongation at break [3]	%	50
- peel strength [2]	lb/in	91
- peel separation	%	25
Extrusion Fillet Seams		
- shear strength [2]	lb/in	120
- shear elongation at break [3]	%	50
- peel strength [2]	lb/in	78
- peel separation	%	25

Notes for Table B2:
1. Also for hot air and ultrasonic methods
2. Value listed for shear and peel strengths are 4 of 5 specimens; the 5th can be as low as 80% listed values
3. Elongation measurements should be omitted for field testing

APPENDIX C

GEOMEMBRANE QUALITY CONTROL or QUALITY ASSURANCE DOCUMENTATION FORMS

This page intentionally left blank.

The following forms are included and shall be completed by the responsible party as shown on the forms, unless otherwise approved by the Engineer:

Form No.	Title
CQC - 100	Liner Project QC Log
CQC - 101	Subgrade Surface Acceptance
CQC - 102	Receiving QC Log
CQC - 103	Personnel QC Log
CQC - 104	Daily Panel Placement QC Log
CQC - 105	Daily Seaming QC Log
CQC - 106	Daily QC Report Pre-weld Testing
CQC - 107	Damage and Failure Log

FORM CQC - 100
LINER PROJECT QC LOG
(one sheet per project)

PROJECT NAME: _____

PROJECT NUMBER: _____ INSTALLATION DATE: _____

PROJECT LOCATION: _____

PROJECT OWNER: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

ENGINEERING FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

GENERAL CONTRACTOR: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

SPECIFIED LINER MATERIALS: _____ THICKNESS & TYPE: _____

SUPPLIER OF LINER MATERIALS: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

MATERIAL CERTIFICATION RECEIVED: _____

DATE: _____ ACCEPTED: _____

FABRICATOR OF MATERIAL: _____

INSTALLER OF MATERIAL: _____

QC INSPECTION FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

LINER TESTING LABORATORY: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

FORM CQC - 101
SUBGRADE SURFACE ACCEPTANCE
(one sheet per Day of Liner Deployment)

PROJECT NAME: _____ DATE: _____ PROJECT NUMBER: _____

EARTH CONTRACTOR: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

GEOMEMBRANE INSTALLER: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

CERTIFICATE OF ACCEPTANCE
OF SUBGRADE SOIL BY INSTALLER

I the undersigned, duly authorized representative of _____do hereby accept the soil surface as being acceptable for the placement of a geomembrane liner.

_____	_____	_____	_____
Name	Signature	Title	Date

Certificate Accepted by Inspector - Company: _____

_____	_____	_____	_____
Name	Signature	Title	Date

QC INSPECTOR: _____

SITE SUPERVISOR: _____

INSTALLING SUPERVISOR: _____

Use back for comments.

FORM CQC - 102
RECEIVING QC LOG
(one sheet per truck)

PROJECT NAME: _____

DATE: _____ TIME: _____ PROJECT NUMBER: _____

TRUCKERS ID: _____

NO. OF PIECES ON BOARD: _____ AGREE WITH PACKING LIST? _____

CONDITION OF PACKAGING: _____

VERIFY PROPER MATERIALS: _____ VERIFY PROPER THICKNESS: _____

IDENTIFY PANEL NUMBERS: _____

_____

IDENTIFY ACCESSORIES *(adhesive, battens, boots, etc.)*: _____

_____

IDENTIFY DAMAGED ITEMS: _____

_____

TYPE OF UNLOADING EQUIPMENT USED: _____

CONDITION: _____

OPERATOR: _____

COMMENTS: _____

_____

STORAGE AREA

CONDITION *(surface)*: _____

LOCATION TO PLACEMENT AREA: _____

MATERIAL PROPERLY COVERED: _____

WEATHER

CONDITIONS: _____ TEMP: _____

QC INSPECTOR: _____

SITE SUPERVISOR: _____

Use back for other comments.

FORM CQC - 103
PERSONNEL QC LOG
(installation & field seaming personnel)
(one sheet per mobilization or change of personnel)

PROJECT NAME: _____

DATE: _____ PROJECT NUMBER: _____

SAFETY MEETING CONDUCTED ON MATERIALS HANDLING: _____

GIVEN BY: _____ DATE: _____

SUPERINTENDENT OF INSTALLATION: _____

SEAMING CREW PERSONNEL

#1 CREW LEADER: _____ HELPER: _____

#2 CREW LEADER: _____ HELPER: _____

#3 CREW LEADER: _____ HELPER: _____

#4 CREW LEADER: _____ HELPER: _____

#5 CREW LEADER: _____ HELPER: _____

#6 CREW LEADER: _____ HELPER: _____

#7 CREW LEADER: _____ HELPER: _____

#8 CREW LEADER: _____ HELPER: _____

OTHER CREW MEMBERS

NAME: _____ NAME: _____

NAME: _____ NAME: _____

NAME: _____ NAME: _____

SIGNED: _____

QC Inspector

FORM CQC – 104
DAILY QC REPORT
PRE-WELD TESTING
(field seam test sample, one per day)

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

TIME	AMBIENT TEMP.	WEATHER	WIND	SEAM TECH INIT.	MACHINE			DESTRUCTIVE TEST						PASS /FAIL	INSP. INITIALS
					ID NO.	TEMP	SPEED	PEEL			SHEAR				

FORM CQC – 105
PANEL PLACEMENT AND SEAMING LOG

DAILY TOTALS: Liner _____Sq. ft., Length Seamed _____ Ft., No. Destructs Marked _____, Anchor Trench: Dug _____ Accepted _____

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

				SEAMS									
TIME	PANEL NO.	ROLL NO.	LENGTH	SEAM NO.	LENGH	TIME	SEAMER TECH.	MACHINE ID NO.	TEMP	SPEED	AMBIENT TEMP.	WIND	WEATHER

COMMENTS: _____

FORM CQC – 106
NON-DESTRUCTIVE TESTING

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

DATE	TECH.	PANEL NO.	SEAM NO.	START FOOTAGE	END FOOTAGE	AIR TEST			AIR LANCE OR VACUUM TEST PASS/FAIL
						START PSI	FINISH PSI	DROP IN PSI OVER 5 MIN.	

FORM CQC – 107
DAMAGE AND FAILURE REPORT

DATE _____ JOB NAME _____ JOB NO. _____ PAGE _____						
PANEL NO.	SEAM NO.	LOCATION OF REPAIR OR DAMAGE	TYPE OF DAMAGE	INSPECTION DATE	MFSM INITIALS	EFR INITIALS

COMMENTS: _____

END OF SECTION

SECTION 02777

LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install textured (on both sides) Linear Low Density Polyethylene (LLDPE) liner cap system as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill and Compaction

B Section 02280: Infiltration Layer

C Section 02701: Drainage and Erosion Layer

D Section 02274: Geocomposite Drainage Net

1.03 SUBMITTALS

A Within 15 calendar days following the Effective Date of the Agreement, submit the following information in accordance with Section 01340:

1. Submittals relating to liner manufacturer and liner

    a. Corporate Background

    b. Manufacturing capabilities:

        (1) Information on factory size, equipment, personnel, number of shifts per day and production capacity per shift.

        (2) List of material properties and samples of liner with attached certified test results.

        (3) Manufacturer's quality control program and manual including description of laboratory facilities.

        (4) A list of ten completed facilities totaling a minimum of three million square feet, for which the manufacturer has manufactured a LLDPE liner. The following information shall be provided for each facility.

- Name and purpose of facility, its location and date of installation
- Name of Owner, project manager, design engineer and installer.
- Liner thickness and surface area
- Information on performance of the facility

c. The origin of the resin to be used in the manufacturing of liner including the supplier's name and production plant, as well as brand name and number.

d. A fingerprint of the manufacturer's liner properties as listed in Appendix A, Table A1. The purpose of these tests is to identify the manufacturer's liner product. The results of these tests shall be submitted to the Engineer for approval of the product. Once the product is approved, all LLDPE liner to be supplied for the Project shall be manufactured using the same resin type identified through fingerprinting tests.

e. Certification that all resin used in the manufacture of LLDPE liner for this Project meets the approved fingerprinting protocol.

f. Copy of quality control certificates in conformance with Paragraphs 2.01 and 2.02.

g. Certification that the LLDPE liner and extrudate produced for this project has the same properties.

2. Submittals relating to installing Contractor

a. Background Information

b. Installation capabilities:

(1) Information on equipment (including tensiometer certification) and personnel.

(2) Anticipated average daily production (Complete including QC measures).

(3) A minimum of three field seam samples and a list of minimum values for seam properties.

c. A list of five completed facilities totaling two million square feet for which the installer has installed LLDPE liner. The following information shall be provided for each facility:

(1) Name and purpose of facility, its location and date of installation.

(2) Name of Owner, design engineer, manufacturer and name and telephone number of contact at the facility who can discuss the project.

(3) Thickness of liner and surface area of the installed liner.

(4) Type of seaming, patching and tacking equipment.

(5) A copy of the manufacturer's certification or approval letter.

(6) Resume of the qualifications of the Installation Supervisor and Master Seamer, and Quality Control personnel to be assigned to this project.

d. Shop drawings, including:

(1) Proposed panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings.

(2) Details of seaming the liner, anchoring, connections, penetrations and other construction details.

e. Installation schedule.

f. A quality control manual that specifically defines the quality assurance program during installation. The manual shall include daily procedures, welding techniques, field testing procedures, lab testing procedures, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and all other information necessary to ensure a high quality liner installation.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

2. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

3. ASTM D5994 - Standard Test Methods for Measuring Core Thickness of Textured Geomembrane

4. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

5. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

6. ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature.

7. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

8. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

9. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

10. ASTM D1693 - Standard Test Method for Environmental Stress - Cracking of Ethylene Plastics.

11. ASTM D3015 - Standard Practice for Microscopic Evaluation of the Dispersion of Carbon Black in Polylefin Geosynthetics.

12. ASTM D3895 - Standard Test Method for Copper-Induced Oxidative Induction Time of Polyolefins by Thermal Analysis.

13. ASTM D4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

14. ASTM D6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

B GRI Test Method GM17 – Test Methods, Test Properties and Testing Frequencies for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

C GRI Test Method GM19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

D Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A In addition to manufacturer and installer requirements for qualifications and certification specified in Paragraph 1.03 the Quality Assurance Plan consists of conformance testing of the material delivered to the site and field quality control during installation.

B Conformance testing requirements are specified in Paragraph 2.03. The purpose of conformance testing is to assure that the supplied material conforms to the specifications and to the manufacturer's quality control certificates.

C Field quality control requirements are specified in Paragraph 3.06. The purpose of field quality control procedures is to assure that the liner has been installed in accordance with the specifications and manufacturer's recommendations.

D Quality Control Plan

1. The forms in Appendix C for liner quality control documentation shall be used for field installation documentation. Alternative forms, which provide the same level of detail, may be used for documentation as approved by the Engineer.

E Geomembrane Quality Control Documentation

1. Pre-installation Conference

a. Prior to commencing work, a pre-installation conference shall be held and the following project personnel shall be identified by name and recorded in the project files:

- Contractor
- Contractor's Representative
- CQA Engineer
- Resident Project Representative (RPR)
- Installation Supervisor: Quality Control Personnel
- Installer
- CQC Officer

b. Two duplicate project files shall be maintained. One shall be maintained by the Resident Project Representative (RPR) and the other shall be maintained by the Installation Supervisor. At the end of each work week the files shall be updated and checked to assure that copies of all pertinent project information is included in each file.

c. Blank copies of the following nine project forms shall be available onsite throughout the duration of the project:

Form No.	Title
100	Liner Project QC Log
101	Subgrade Surface Acceptance

102 Receiving QC Log
103 Personnel QC Log
104 Pre-Weld Testing
105 Daily Panel Placement and Seaming QC Log
106 Air Testing Log
107 Vacuum Testing Log

F Record Drawings

1. The Contractor shall furnish record drawings showing changes, if any, from the approved installation drawings which are to include all destructive sample locations (if performed), any patches used to repair liner defects, and all panel and patch identifications assigned in the field; and a copy of complete documentation for final installation of the liner.

1.06 QUALIFICATIONS

A Manufacturer

1. The manufacturer of the lining material described hereunder shall have previously demonstrated his/her ability to produce this liner by having at least five years continuous experience in the manufacture of LLDPE liner and successfully manufactured a minimum of 50 million square feet of similar liner material for hydraulic lining installations. The manufacturer must be certified and registered by GRI GM17 Standard as meeting all the requirements for manufacturing LLDPE liner.

B Installer

1. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's liner. Installation shall be performed under the constant direction of a single installation supervisor who shall remain on site and be in responsible charge, through the liner installation, for liner layout, seaming, patching, testing, repairs and all other activities required by the installer. The installation supervisor shall have installed or supervised the installation and seaming of a minimum of two million square feet of LLDPE liner or similar liner.

1.07 DELIVERY, STORAGE AND HANDLING

A The liner rolls shall be packaged and shipped by appropriate means to prevent damage of the liner rolls. Off-loading and storage of the liner is the responsibility of the Contractor. The liner rolls shall be unloaded in the presence of the CQA Officer (RPR). The Contractor shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.

B Damage during off-loading shall be documented by the CQA Officer (RPR). All damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined by the Engineer.

C The liner rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions and excessive heat that may damage the liner material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

1.08 MATERIAL WARRANTY

A The LLDPE liner manufacturer shall warrant the liner, on a prorated basis, against manufacturing defects and material degradation under outdoor exposure for a period of five years from the date of installation. The manufacturer shall replace at no expense any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the LLDPE liner against defects in installation and workmanship for the period of two years commencing with the date of final acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

1.10 DEFINITIONS AND RESPONSIBILITIES

A Contractor

1. The Contractor is the firm or corporation with whom the Owner has entered into agreement to construct the project. The Contractor is responsible for all submittals by the manufacturer and the installer as required by the Specifications. The Contractor is responsible for scheduling and coordination of the required work with the manufacturer and the installer to complete the project. The Contractor is responsible for furnishing as built drawings and a copy of the complete documentation of the liner system. The Contractor is also responsible for daily updating of the design drawings onsite and for any and all deviations from these drawings.

B Manufacturer

1. The manufacturer is the firm or corporation responsible for production of the liner material to be used in the project. The manufacturer shall produce a consistent product meeting the project specifications, and shall provide quality control documentation for the product specified herein. The Manufacturer shall produce a consistent product meeting the project specifications.

C Installer

1. The installer is the firm responsible for installation of the liner. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's geomembrane. The Installer shall be responsible for field handling, storing, placing, seaming, field testing and all other aspects of the liner installation.

PART 2: PRODUCTS

2.01 MATERIALS

A General

1. The textured (both sides) liner shall be manufactured of new, prime first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and chemically resistant to leachate.

2. The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

3. The sheets shall be manufactured in a minimum 15-ft seamless width. Labels on the roll shall identify the thickness, length, width, roll number and manufacturer's lot number.

4. The textured sheet must not delaminate during tensile testing (i.e., textured layers and "particles" of texture must not separate).

B Properties

1. The liner rolls shall meet the minimum properties listed in Appendix B, Table B1.

C Other Materials

1. Extrudate welding rods shall be of the same compound as the liner and supplied by the manufacturer and shall be delivered in the original sealed containers. Each container shall have a label bearing the brand name, manufacturer's lot number and complete directions as to proper storage.

2.02 QUALITY CONTROL DOCUMENTATION

A Prior to installation commencement of any liner material, the Contractor shall provide the following information certified by the manufacturer for the delivered liner.

1. Origin, identification and production of the resin (supplier's name, brand name and production plant).

2. Copies of quality control certificates issued by the resin supplier.

3. Manufacturer's certification verifying that the quality of the resin used to manufacture the liner meets the fingerprint properties shown in Appendix A, Table A1.

4. Each roll delivered to the project site shall have the following identification information:

   - Manufacturer's name
   - Product identification
   - Thickness
   - Roll number

5. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, frequency and test results. At a minimum the following test results shall be provided in accordance with test requirements specified in Appendix B:

   - Thickness
   - Density
   - Tensile properties
   - Tear resistance
   - Carbon black content

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by CQA personnel and an independent Quality Assurance Laboratory approved by the Owner. One sample shall be taken by CQA personnel per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. The Engineer shall obtain the samples from the roll, and mark the machine direction and identification number. The following conformance tests shall be conducted at the laboratory:

   - Thickness
   - Density
   - Tensile properties
   - Tear resistance
   - Carbon black content

B These conformance tests shall be performed in accordance with Appendix B. All costs for the initial conformance testing will be paid by the Owner.

C All conformance test results shall be reviewed by Engineer and accepted or rejected, prior to the placement of the liner. All test results shall meet, or exceed, the property values listed in Appendix B. In case of failing test results,

the manufacturer may request that another sample be retested by the independent laboratory with manufacturer's technical representative present during the testing procedures. This retesting shall be paid for by the manufacturer. The manufacturer may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted. If both laboratories do not report passing results, all liner material from the lot representing the failing sample will be considered out of specification and rejected.

PART 3: EXECUTION

3.01 INFILTRATION LAYER PREPARATION

A Preparation of the infiltration layer surface shall be as specified in Section 02280.

B The surface of the infiltration layer shall be smooth, uniform, free from sudden changes in grade (such as vehicular ruts), rocks, stones, debris and deleterious materials. The moisture content of the infiltration layer must be maintained within the project specifications until the synthetic liner has been installed. If excessive drying occurs, the contractor shall rehydrate and compact the affected area to the Engineer's satisfaction. During actual placing and seaming of the liner, the infiltration layer surface shall be kept free of all standing water. If the infiltration layer surface below the liner becomes wet and unstable, it shall be dried and re-compacted to the Engineer's satisfaction. If drying and re-compacting the material is insufficient, the unstable material must be removed and replace with approved material

C Before the liner installation begins, the Contractor and installer shall verify in writing and submit to the Engineer:

1. Lines and grades are in conformance with the Drawings and Specifications.

2. The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

D The Contractor shall not proceed with synthetic liner installation until a complete report on the infiltration layer thickness and hydraulic conductivity tests has been submitted and approved by the Engineer. If the Contractor proceeds with synthetic liner installation and associated layers (drainage net, geotextile and protective cover) prior to completion of the report, the Contractor will do so at his/her own risk. If any infiltration layer tests fail, the Contractor will be required to remove overlying liner system layers, repair deficient infiltration layer area(s) and reinstall the liner system in accordance with project specification requirements. Any liner system materials damaged during the repair work shall be replaced with new material. All costs associated with such actions will be paid for entirely by the Contractor including, but not limited to,

labor, additional liner system material, testing, labor and material costs incurred by the Engineer to perform additional inspection services.

3.02 ANCHOR TRENCH

A The anchor trench shall be constructed as shown on the Drawings and as specified herein.

B Slightly rounded corners shall be provided in the trench to avoid sharp bends in the liner.

C The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with local fill material and compacted to 92 percent standard proctor density, ASTM D698 as specified in Section 02200.

D If the anchor trench is located in a clayey material susceptible to desiccation, the amount of trench open at any time shall be limited to one day of liner installation capacity.

3.03 LINER PLACEMENT

A Weather Conditions

1. Liner placement shall not proceed at an ambient temperature below 40 degrees F or above 104 degrees F unless otherwise authorized, in writing, by the Engineer or his/her field representative. Liner placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or excessive winds.

B Method of Placement

1. Each Liner panel shall be layed out in accordance with the approved shop drawings prepared by the Manufacturer. The layout shall be designed to keep field joining of the LLDPE liner to a minimum and consistent with proper methods of LLDPE liner installation.

2. Each liner panel shall be identified by panel number, roll number and date of deployment. The liner panel number shall be placed on the ends of each panel and in the middle.

3. For liner placed on 4 to 1 or steeper slopes, the seams shall be oriented in the direction of the slope. Horizontal seams on 4 to 1 slopes or steeper shall not be allowed except for cases in which it is unavoidable. In these instances, a cap strip shall be placed over the seam.

4. The equipment used to deploy the liner shall not cause rutting of the infiltration layer surface. If rutting occurs, the Contractor shall suspend

all liner placement activities and repair the ruts and immediately employ an alternative method for liner deployment. Liner rolls shall be placed using spreader and rolling bars with cloth slings. If a sheet must be relocated a distance greater than its width, a slip sheet shall be used.

5. The RPR shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the Engineer.

6. The installer shall not drag the liner panels over the infiltration layer.

7. All liner shall be anchored as shown on the Drawings and consistent with manufacturer's recommendations. Sufficient liner shall be installed within the anchor trench to ensure proper installation prior to backfilling the trench.

8. Personnel working on the liner shall not smoke, wear damaging shoes or involve themselves in any activity that may damage the liner.

9. The liner shall be properly weighted with sand bags to avoid uplift due to wind.

10. Vehicular traffic across the liner shall not be allowed.

11. All damage shall be recorded and located on the record drawings.

12. When tying into existing liner, all excavation of previously installed liner shall be performed by hand to prevent damage.

13. The liner shall be kept free of debris, unnecessary tools and materials. In general, the liner area shall remain uncluttered in appearance. Any generators in use while on the liner shall have "drop" sheets place underneath.

14. Fuel shall not be stored on the liner.

15. To prevent a "trampoline effect" from forming, the Contractor shall place sufficient sand bags on the liner along the toe of slopes to ensure full contact of the geomembrane liner with the infiltration layer surface. In addition, the horizontal seams nearest the toe of slope shall remain un-welded until all other seams in the area are completed. The final seam shall be welded when the liner is cool and fully contracted. Care shall be taken to ensure that the liner contacts the subgrade in all locations before completing the seam.

3.04 FIELD SEAMS

A Individual panels of liner shall be laid out and overlapped by a minimum of 4-in prior to welding. The area to be welded shall be cleaned and prepared in accordance with the installer's quality control welding procedures.

B Double track hot wedge fusion welder shall be used for straight welds.

C Extrusion welder shall be used for cross seam tees, patches, repairs, penetration boots and detailed work.

D The welding equipment used shall be capable of continuously monitoring and controlling the temperature speed, and pressure in the zone of contact where the machine is actually fusing the liner material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

E No "fish mouths" will be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped and a patch fusion weld shall be applied. All welds upon completion of the work shall be tightly bonded. Any liner area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of liner. The number of patches per 100-ft length shall not exceed five. If more than five patches per 100-ft length are necessary, then the entire 100-ft length of seam shall be removed. Further welding will cease at this time and the Engineer shall be notified.

F All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be welded together.

G All fusion welded "T" seams (i.e., the result of the liner panels placed perpendicular to each other) shall be double welded where possible. The extrusion process shall be used for the second weld.

H All extrudate shall be free of dirt, dry and protected from damage.

I If an extrusion welder is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extradite shall be placed on a sacrificial sheet and disposed of.

J All seams constructed on sloped surfaces shall be vertical seams. Where horizontal seams can't be avoided (due to compounded slopes) on sideslope surfaces, a 18" wide cap strip of the same synthetic material shall be placed on top of the horizontal seam and welded to the adjacent panels to provide additional structural integrity. All cap strip seams shall be non-destructively tested.

K All vertical panels placed on sloped surfaces shall extend 5-ft inward from the toe of slope or edge of trench.

L All end seams shall be staggered a minimum of 5-ft in length between contiguous panels.

M To prevent moisture buildup during fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of liner that is to be seamed.

N If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

O All seams shall extend to the full extent into the anchor trench.

P All factory seams, field seams and repair welds shall meet seam strength requirements specified in Appendix B, Table B2.

3.05 SEAMING WEATHER CONDITIONS

A Normal Weather Conditions

1. The normal required weather conditions for seaming are:

   a. Ambient temperature higher than 40 degrees F and lower than 104 degrees F.

   b. No precipitation or other excessive moisture, such as fog or dew.

   c. No excessive winds.

2. These weather conditions shall be fulfilled during seaming process.

B Cold Weather Conditions

1. If the ambient temperature is below 40 degrees F, the following conditions shall be met to ensure quality seaming process:

   a. Preheating the surface of the liner to achieve normal temperature range.

   b. Preheating may be waived by the Engineer or the RPR if the installer demonstrates that satisfactory welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

   c. Preheating devices shall be approved by the manufacturer.

   d. Care shall be taken to assure that surface temperatures are not lowered below the minimum required surface temperature for welding due to winds.

e. Additional destructive tests samples shall be taken at the discretion of the CQA Engineer.

f. Test seams, as described in Paragraph 3.06A, shall be performed under the same ambient temperature conditions as the actual seams.

C Warm Weather Conditions

1. If the ambient temperature is above 104 degrees F, no seaming of liner shall be permitted unless the installer can demonstrate, to the satisfaction of the Engineer that liner seam quality is not adversely impacted.

2. Test seams shall be performed under the same ambient temperature conditions as the actual seams.

3. Additional destructive tests shall be taken at the discretion of the CQA Engineer.

3.06 FIELD QUALITY CONTROL

A Pre-weld Testing

1. A test weld 3-ft long from each welding machine shall be run upon the beginning of each shift and every four hours thereafter, under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature and welder's name, temperature and speed, welding machine number. A tensiometer shall be required to be on-site before and during liner installation for the purpose of testing samples. Six specimens of welds 1-in wide shall be cut from the test weld and tested on site with the presence of the RPR for shear and peel strength (3 each) in accordance with Appendix B, Table B-2. No welder may start work until the sample weld has been approved by the RPR.

2. Test seams shall be performed under the same conditions as the actual seams and shall be at least 3-ft long, 1-ft wide after seaming. Test seam for welding shall be cut out of the liner rolls.

B Non-destructive Seam Testing

1. The installer shall perform nondestructive test on all field seams over their full length. The purpose of this test is to assure continuity and integrity of the seams. Vacuum and air pressure tests shall be used for nondestructive testing. The vacuum test shall be used for extrusion welds and single track hot wedge welds. The air pressure test shall be used for double track hot wedge welds.

2. Vacuum Testing

   a. Equipment for testing single wedge fusion seams and extrusion seams shall be comprised of the following:

      (1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gage.

      (2) A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

      (3) A rubber pressure/vacuum hose with fittings and connections.

      (4) A plastic bucket and wide paint brush.

      (5) A soapy solution.

   b. The following procedures shall be followed by the installer:

      (1) Excess sheet overlap shall be trimmed away.

      (2) Clean the window, gasket surfaces and check for leaks.

      (3) Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.

      (4) Wet a strip of liner approximately 12-in by 48-in (length of box) with the soapy solution.

      (5) Place the box over the wetted area and compress.

      (6) Close the bleed valve and open the vacuum valve.

      (7) Ensure that a leak-tight seal is created.

      (8) For a minimum period of ten seconds, examine the liner through the viewing window for the presence of soap bubbles.

      (9) If no bubbles appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 3-in overlap and repeat the process.

      10) All areas where soap bubbles appear shall be marked and repaired in accordance with Paragraph 3.07G and then retested.

11) All test locations which have passed vacuum testing shall be marked with the test date and individual performing the test.

c. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the RPR for uniformity and completeness.

3. Air Pressure Testing.

a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.

b. Equipment for testing double fusion seams shall be comprised of the following:

(1) An air pump equipped with pressure gage capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the liner.

(2) A manometer equipped with a sharp hollow needle, or other approved pressure feed device.

c. The following procedures shall be followed by the installer.

(1) Seal both ends of the seam to be tested.

(2) Insert needle or other approved pressure feed device into the tunnel created by the double wedge fusion weld.

(3) Energize the air pump to a pressure between 27 and 40 psi, close valve and sustain pressure for at least five minutes.

(4) If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair in accordance with Paragraph 3.07G and retest.

(5) If the faulty area cannot be isolated and repaired, the length of seam which can not be tested shall be capped with liner strip, extrusion welded and vacuum tested. The seam shall be documented as a failed seam indicating the corrective measure.

(6) If loss of pressure is 3 psi or less, release air pressure at the opposite end of where the pressure is applied to verify that the full seam was pressurized and that there was no blockage in the air channel.

(7) Remove needle or other approved pressure feed device and seal.

(8) All test locations which have passed air pressure testing shall be marked with the test date and individual performing the test.

3.07 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

APPENDIX A

TABLE A1

FINGERPRINTING PROPERTIES FOR TEXTURED (BOTH SIDES)

LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PROPERTY	TEST METHOD
Density	ASTM D1505 ASTM D792
Melt Flow Index	ASTM D1238
Carbon Black Content	ASTM D4218

The above tests shall be performed by the manufacturer of the textured LLDPE liner for identification of the manufacturer's product. The above test results shall be submitted to the Engineer for approval of the product. The resin to be supplied for the project shall meet the properties and test values as listed by GRI-GM17, or its latest version.

Note: The CONTRACTOR may submit a proposal(s) for the use of alternate test methods to determine required material properties specified in Table A1. Proposed alternate test methods shall conform to current industry standards. Proposals will be reviewed by ENGINEER and ENGINEER will notify CONTRACTOR, in writing, of decision to accept or reject the proposal(s). Requests for additional costs based on submission of, acceptance of, or rejection of proposal will not be allowed.

APPENDIX B

TABLE B1
MATERIAL PROPERTIES
TEXTURED LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

TEST

PROPERTY	UNIT	LIMIT	METHOD	VALUE
Thickness	mils	min. ave[1]	ASTM D5994	40
Density	g/cc	max.	ASTM D1505	0.939
Tensile Properties (Each Direction)			ASTM D6693	
1. Break Strength	lb/in	min.		60
2. Elongation at Break	%	min.		250
Tear Resistance	lb	min.	ASTM D1004	22
Puncture Resistance	lb	min.	ASTM D4833	44
Carbon Black Content	%	min.	ASTM D4218	2.0-3.0
Oxidative Induction Time	minutes	min.	ASTM D3895	≥100
Interface[2] Friction	deg.	min.	ASTM D5321	27°

Notes:

1. Refer to GRI Test Method GM17 for acceptable ranges and values
2. (Textured LLDPE to Geocomposite Drainage Net) Use same Geocomposite Drainage Net as proposed by the Contractor for this project.

TABLE B2

FACTORY AND FIELD SEAMS PROPERTIES
LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PROPERTY	UNIT	TEST METHOD	MINIMUM VALUE
Bonded Shear Strength:	lb/in	ASTM D6392	No AD Breaks and 60
Seam Peel Adhesion (hot wedge):	lb/in	ASTM D6392	No AD Breaks and 50
Seam Peel Adhesion (extrusion):	lb/in	ASTM D6392	No AD Breaks and 45

Note: Refer to GRI-GM19 in its latest version for properties and values

This page intentionally left blank

APPENDIX C

GEOMEMBRANE
QUALITY CONTROL FIELD REPORTS

CQC FIELD REPORTS

The following forms are included and shall be completed by the responsible party as shown on the forms. Alternate forms with pertinent content and format may be used as approved by the CQA Officer.

Form No.	Title
CQC - 100	Liner Project QC Log
CQC - 101	Subgrade Surface Acceptance
CQC - 102	Receiving QC Log
CQC - 103	Personnel QC Log
CQC - 104	Pre-Weld Testing
CQC - 105	Daily Panel Placement and Seaming QC Log
CQC - 106	Non-destructive Testing Log
CQC - 107	Damage and Repair Report

FORM CQC - 100
LINER PROJECT QC LOG
(one sheet per project)

PROJECT NAME: _____

PROJECT NUMBER: _____ INSTALLATION DATE: _____

PROJECT LOCATION: _____

PROJECT OWNER: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

ENGINEERING FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

GENERAL CONTRACTOR: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

SPECIFIED LINER MATERIALS: _____ THICKNESS & TYPE: _____

SUPPLIER OF LINER MATERIALS: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

MATERIAL CERTIFICATION RECEIVED: _____

DATE: _____ ACCEPTED: _____

FABRICATOR OF MATERIAL: _____

INSTALLER OF MATERIAL: _____

QC INSPECTION FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

LINER TESTING LABORATORY: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

FORM CQC - 101
SUBGRADE SURFACE ACCEPTANCE
(one sheet per Day of Liner Deployment)

PROJECT NAME: _____ DATE: _____ PROJECT NUMBER: _____

EARTH CONTRACTOR: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

GEOMEMBRANE INSTALLER: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

CERTIFICATE OF ACCEPTANCE
OF SUBGRADE SOIL BY INSTALLER

I the undersigned, duly authorized representative of _____do hereby accept the soil surface as being acceptable for the placement of a geomembrane liner.

_____	_____	_____	_____
Name	Signature	Title	Date

Certificate Accepted by Inspector - Company: _____

_____	_____	_____	_____
Name	Signature	Title	Date

QC INSPECTOR: _____

SITE SUPERVISOR: _____

INSTALLING SUPERVISOR: _____

Use back for comments.

FORM CQC - 102
RECEIVING QC LOG
(one sheet per truck)

PROJECT NAME: _____

DATE: _____ TIME: _____ PROJECT NUMBER: _____

TRUCKERS ID: _____

NO. OF PIECES ON BOARD: _____ AGREE WITH PACKING LIST? _____

CONDITION OF PACKAGING: _____

VERIFY PROPER MATERIALS: _____ VERIFY PROPER THICKNESS: _____

IDENTIFY PANEL NUMBERS: _____

_____

IDENTIFY ACCESSORIES *(adhesive, battens, boots, etc.)*: _____

_____

IDENTIFY DAMAGED ITEMS: _____

_____

TYPE OF UNLOADING EQUIPMENT USED: _____

CONDITION: _____

OPERATOR: _____

COMMENTS: _____

_____

STORAGE AREA

CONDITION *(surface)*: _____

LOCATION TO PLACEMENT AREA: _____

MATERIAL PROPERLY COVERED: _____

WEATHER

CONDITIONS: _____ TEMP: _____

QC INSPECTOR: _____

SITE SUPERVISOR: _____

Use back for other comments.

FORM CQC - 103
PERSONNEL QC LOG
(installation & field seaming personnel)
(one sheet per mobilization or change of personnel)

PROJECT NAME: _____

DATE: _____ PROJECT NUMBER: _____

SAFETY MEETING CONDUCTED ON MATERIALS HANDLING: _____

GIVEN BY: _____ DATE: _____

SUPERINTENDENT OF INSTALLATION: _____

SEAMING CREW PERSONNEL

#1 CREW LEADER: _____ HELPER: _____

#2 CREW LEADER: _____ HELPER: _____

#3 CREW LEADER: _____ HELPER: _____

#4 CREW LEADER: _____ HELPER: _____

#5 CREW LEADER: _____ HELPER: _____

#6 CREW LEADER: _____ HELPER: _____

#7 CREW LEADER: _____ HELPER: _____

#8 CREW LEADER: _____ HELPER: _____

OTHER CREW MEMBERS

NAME: _____ NAME: _____

NAME: _____ NAME: _____

NAME: _____ NAME: _____

SIGNED: _____

QC Inspector

FORM CQC – 104
DAILY QC REPORT
PRE-WELD TESTING
(field seam test sample, one per day)

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

TIME	AMBIENT TEMP.	WEATHER	WIND	SEAM TECH INIT.	MACHINE			DESTRUCTIVE TEST						PASS /FAIL	INSP. INITIALS
					ID NO.	TEMP	SPEED	PEEL			SHEAR				

FORM CQC – 105
PANEL PLACEMENT AND SEAMING LOG

DAILY TOTALS: Liner _____Sq. ft., Length Seamed _____ Ft., No. Destructs Marked _____, Anchor Trench: Dug _____ Accepted _____

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____													
				SEAMS									
TIME	PANEL NO.	ROLL NO.	LENGTH	SEAM NO.	LENGH	TIME	SEAMER TECH.	MACHINE ID NO.	TEMP	SPEED	AMBIENT TEMP.	WIND	WEATHER

COMMENTS: _____

FORM CQC – 106
NON-DESTRUCTIVE TESTING

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

DATE	TECH.	PANEL NO.	SEAM NO.	START FOOTAGE	END FOOTAGE	AIR TEST			AIR LANCE OR VACUUM TEST PASS/FAIL
						START PSI	FINISH PSI	DROP IN PSI OVER 5 MIN.	

FORM CQC – 107
DAMAGE AND FAILURE REPORT

DATE _____		JOB NAME _____		JOB NO. _____		PAGE _____
PANEL NO.	SEAM NO.	LOCATION OF REPAIR OR DAMAGE	TYPE OF DAMAGE	INSPECTION DATE	MFSM INITIALS	EFR INITIALS

COMMENTS: _____

END OF SECTION

SECTION 02985

STABILIZATION

PART 1: GENERAL

1.01 WORK INCLUDED

The CONTRACTOR shall furnish all labor, materials, equipment, soil analysis, and incidentals necessary to finish grade, seed, and maintain all seeded areas as specified herein including all areas disturbed by the CONTRACTOR'S operations.

1.02 SUBMITTALS

A Submit to the ENGINEER for review complete shop drawings for all materials and equipment furnished under this Section, including but limited to soil analysis and recommended seed mixtures, application rates, admixtures, fertilizers and product label information.

1. A soil analysis is required prior to all permanent cover operations; the soil analysis should be used to determine suitable grasses and adequate application rates of lime and fertilizers.

2. The CONTRACTOR will create a seeding plan and determine all rates of application necessary to produce the required stand of grass

B Samples of all materials shall be submitted for inspection and acceptance upon ENGINEER'S request.

C The CONTRACTOR shall submit a certified survey in accordance with Section 01050.

D Certification from seed vendor for each seed mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for sod, identifying sod source, including name and telephone number of supplier.

E. Certification by Limestone and Fertilizers manufacturer that the products supplied comply with requirements:

PART 2: PRODUCTS

2.01 MATERIALS

A Fertilizer shall be complete commercial fertilizer, 10-10-10 grade or as otherwise based on the soil analysis and accepted. It shall be delivered to the site in the original unopened containers each showing the manufacturer's guaranteed analysis. Store fertilizer so that when used it shall be dry and free flowing.

B Lime: ASTM C 602, Class T, agricultural limestone in the form of dolomitic limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 sieve and a minimum 75 percent passing a No. 60 sieve.

C Seed shall be from the same or previous year's crop; each variety of seed shall have a percentage of germination not less than 90, a percentage of purity not less than 85, and shall have not more than one percent weed content.

D The seed shall be furnished and delivered premixed in the proportions specified in Paragraph 3.02 E. A manufacturer's certificate of compliance to the specified mixes shall be submitted by the manufacturer for each seed type. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the CONTRACTOR has submitted the certificates.

E Seed shall be delivered in sealed containers bearing the dealer's guaranteed analysis.

F Mulch shall be one of the following:

1. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

2. Peat Mulch: Provide peat moss in natural, shredded, or granulated form, of fine texture, with a pH range of 4 to 6 and a water-absorbing capacity of 1100 to 2000 percent.

3 Fiber Mulch: Biodegradable dyed-wood cellulose-fiber mulch, nontoxic, free of plant growth- or germination-inhibitors, with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

G Tackifier shall be one of the following.

1 Asphalt Emulsion Tackifier: Asphalt emulsion, ASTM D 977, Grade SS-1, nontoxic and free of plant growth- or germination-inhibitors.

2. Non-asphaltic tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application, nontoxic and free of plant growth- or germination-inhibitors.

PART 3: EXECUTION

3.01 APPLICATION

A Lime shall be applied at the rate of 4000 lbs per acre, or as recommended in reports from a qualified soil testing agency in accordance with the protective cover soils analysis described in Section 02290, item 1.07D.

B Fertilizer shall be applied at the rate of 1000 pounds per acre, or as recommended in reports from a qualified soil testing agency.

3.02 SEEDING

A Seed all disturbed areas of construction (excluding rip-rap lined ditches).

B No seeding should be undertaken in windy or unfavorable weather, when the ground is too wet to rake easily, when it is in a frozen condition, or too dry.

C The subgrade of all areas to be seeded shall be raked and all rubbish, sticks, roots, and stones larger than 2 inches shall be removed.

D Fertilizer shall be uniformly spread and disked or roto-tilled to a depth of at least 4 inches.

E Immediately following this preparation the seed shall be uniformly applied and lightly raked into the surface. Lightly roll the surface and water with fine spray. Seed shall be applied, depending on the period of year, as shown on the engineering drawings:

F. All seeded areas shall be mulched with clean small-grain straw at a rate of 1-1/2 to 2 tons per acre. Asphalt emulsion shall be applied uniformly at a rate of 300 gallons per acre to tack the mulch, unless otherwise shown on the plans. Mechanical tacking will be considered on a case-by-case basis as approved by the ENGINEER.

G. The CONTRACTOR shall keep all seeded areas watered and in good condition. Re-seeding shall be done if and when necessary until a good, healthy, uniform growth is established over the entire area seeded.

H. On slopes, the CONTRACTOR shall provide against washouts by an approved method. Any washout which occurs shall be regraded and reseeded at the CONTRACTOR'S expense until good sod is established.

I. CONTRACTOR is responsible for installing temporary seeding and mulching as required to protect the work prior to the establishment of grass from permanent seeding and mulching. Temporary seeding shall be installed in

accordance with Section 810, SEEDING, of the "South Carolina Department of Transportation Standard Specifications for Highway Construction," edition of 2000.

3.03 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.

1. Mix slurry with nonasphaltic tackifier.

2. Apply slurry uniformly to all areas to be seeded in a 1-step process. Apply mulch at the minimum rate of 1500 lb per acre dry weight but not less than the rate required to obtain specified seed-sowing rate.

3. Apply slurry uniformly to all areas to be seeded in a 2-step process. Apply first slurry application at the minimum rate of 500 lb per acre dry weight but not less than the rate required to obtain specified seed-sowing rate. Apply slurry cover coat of fiber mulch at a rate of 1000 lb per acre.

3.04 MAINTENANCE

A The CONTRACTOR shall maintain all seeded areas in a condition approved by the OWNER and/or ENGINEER until final acceptance of the Contract. Maintenance shall include, but not be limited to, repair of erosion and washed areas, re-seeding and re-applying fertilizer and mulch, irrigation, and weed control. Protection shall be provided for all seeded areas against trespassing and damage. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly.

B All seeded areas shall be inspected on a regular frequency acceptable to the OWNER and any necessary repairs or re-seedings made within the planting season.

END OF SECTION

SECTION 03350

FABRIC-FORMED CONCRETE REVETMENT

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment, and incidentals required for installing of fabric formed concrete revetment (uniform section mat) as shown on the Drawings and as specified herein.

1.02 CONTRACTOR QUALIFICATIONS

A The CONTRACTOR shall furnish records of past successful experience in performing this type of work. The Contractor shall save the Owner harmless from liability of any kind arising from the use of any patented or unpatented invention in the performance of this work.

B The CONTRACTOR shall provide a construction superintendent who is thoroughly familiar with the specified requirements, trained and experienced in the necessary skills, and who shall be present at the site for the duration of the installation and shall direct all work performed under this section.

PART 2: PRODUCTS

2.01 FABRIC FORMWORK

A Fabric formwork material shall be constructed of permeable, continuously woven panels of double-layer, open-salvage synthetic fabric jointed together to form a formwork for placing fine aggregate concrete slurry. The fabric shall consist of synthetic yarns formed into a stable network such that the yarns retain their relative position to each other and withstand the pressure of the grout injection pump without breaking the layers of fabric.

B The fabric formwork shall be furnished as six-inch uniform section mat.

C Individual mill width panels shall be cut to the length required and the two layers of fabric separately joined edge-to-edge by means of sewing thread to form multiple -mill width panels. Multiple-mill width panels shall be field joined edge-to-edge to adjacent panels by means of sewing thread, zippers or hook and loop-type fasteners. The grab tensile strength of all joints shall be not less than 100 lbs. per inch when tested in accordance with ASTM D-1682-75.

D Immediately following receipt of fabric to the jobsite, fabric shall be inspected and stored in a clean, dry area where it will not be subject to mechanical damage, exposure to moisture or direct sunlight.

E At the direction of the ENGINEER, the CONTRACTOR shall demonstrate the suitability of the fabric design by injecting the fine aggregate slurry into a 5-1/2-inch diameter fabric sleeve under pressure at 10 to 15 psi, which shall be maintained by means of air pressure or a standpipe for 10 minutes. The sleeves shall be constructed of a single layer of Uniform Section fabric. Test cylinders, 12-inches long, shall be cut from each specimen and tested in accordance with ASTM C-39.

F The average compressive strength of cast test cylinders shall be at least 20 percent higher at 7 days than that of companion test cylinders made in accordance with ASTM C-31, and not less than 2,500 psi at 28 days.

2.02 MORTAR GROUT

A Fine aggregate concrete shall consist of a mixture of Portland cement, fine aggregate and water so proportioned and mixed as to provide a pumpable slurry. Admixtures and/or a pozzalan may be used with the approval of the ENGINEER.

B Portland cement shall conform to ASTM C-150, Type I or Type II.

C Fine aggregate shall conform to ASTM C-33, except as to grading. Aggregate grading shall be reasonably consistent and shall be well graded from the maximum size which can be conveniently handled with available pumping equipment.

D Water for mixing shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter or other deleterious substances.

E Pozzolan, if utilized, shall conform to ASTM C-618 Type N, F or C.

F Admixtures, if utilized, shall contribute to the nature of the specifications. a water reducer conforming to ASTM C-494 may be used to reduce segregation, increase workability and pumpability, improve strength and increase water tightness. If an air entraining agent is used, it shall conform to ASTM C-260, and it shall improve resistance to freezing and thawing. The air content shall not exceed seven percent of the volume of the grout.

G Materials shall be proportioned to produce a hardened concrete with a minimum compressive strength of 2,500 psi at 28 days when specimens are made and tested in accordance with ASTM C-31 and C-39.

PART 3: EXECUTION

3.01 SLOPE PREPARATION

A Areas on which fabric formwork is to be placed shall be constructed to the lines and grades shown on the Drawings.

B Excavation and preparation of anchor trenches, side trenches, and toe trenches or aprons shall be done in accordance with the lines, grades, and dimensions shown on the Drawings.

3.02 FABRIC FORMWORK PLACEMENT

A Position fabric loosely before grout injection; place an appropriate amount of weight at predetermined locations to allow for fabric compaction. STAKING OF FABRIC WITHIN THE LIMITS OF THE LINER WILL NOT BE PERMITTED. Do not approximate fabric locations.

B Fabric panels are jointed in the field with a bag closer (portable sewing machine). Lay out the first panel and fold back the leading edge. Invert the adjacent abutting panel. Join the top layers of fabric. Join the bottom layers of fabric. Fold the jointed panels back of the bank with seams down.

C To avoid field sewing as much as possible, prepare fabric assembly sketches in such detail that the great majority of the sewing can be done prior to delivery.

D Provide a small quantity of uncut, unassembled fabric for special field tailoring.

3.03 MORTAR GROUT PLACEMENT

A Following panel placement, small cuts shall be made in the top layer of the fabric formwork to allow for the insertion of the injection hose or nozzle. Fine aggregate concrete slurry shall be injected between the top and bottom layers of fabric, inflating the panel to the recommended thickness and configuration.

B Fine aggregate concrete slurry shall be injected in such a way that excessive pressure on the fabric formwork and cold joint within any one panel are avoided.

C Holes in the fabric left by the removal of the injection hose shall be temporarily closed by inserting a piece of burlap similar material. The burlap shall be removed when the concrete is no longer fluid and the surface firm is to the hand. Foot traffic on the filled mat shall be restricted to an absolute minimum for one hour after pumping.

D Upon completion of the concrete placement, all the anchor trenches, side trenches, and toe trenches shall be backfilled, compacted, and completed as

specified. All spilled mortar shall be cleaned up by hand. The mat shall be washed down with a water hose.

3.04 QUALITY CONTROL

A One set of three test cylinders shall be taken each day: one cylinder shall be tested at seven days, two cylinders at 28 days. Copies of the test results shall be furnished to the Engineer.

B The concrete for the test cylinders shall be taken from the injection hose after the fine aggregate concrete has passed through the pump. Test cylinder to consist of nylon fabric in the form of a test sock to give an accurate in-place test result.

END OF SECTION

SECTION 03405

PRE-CAST UTILITY VAULT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included: Provide precast concrete utility vaults where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

B. Related work:

1. Documents affecting work of this Section include, but are not necessarily limited to, Contract Drawings and details theerin, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Qualifications of manufacturer: Demonstrate capability to make and provide the specified quality products by attestation of the Prestressed Concrete Institute under the Plant Certification Program.

C. Referenced manufacturer is Tindall Concrete Products, Inc. Equal precast vaults of other manufacturers conforming to these specifications may be provided with the Engineer's approval.

1.3 SUBMITTALS

A. Comply with pertinent provisions of Section 01340.

B. Product data: Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:

1. Materials list of items proposed to be provided under this Section.
2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
3. Manufacturer's certifications and laboratory test reports required.
4. Shop drawings, prepared in accordance with pertinent provisions of Section 01340 of these Specifications and showing complete

information for fabrication and erection of the work of this Section including, but not necessarily limited to:

a. Member dimensions and cross-sections; locations, size and type of reinforcement, including special reinforcement and lifting devices necessary for handling and erection.
b. Erection procedures, sequence of erection, and required handling equipment.
c. Layout, dimensions, and identification of each precast unit corresponding to the sequence and procedure of installation.
d. Details of inserts, connections, and joints, including accessories and construction at openings in the precast units.
e. Location and details of anchorage devices that are to be embedded in other construction.

1.4 PRODUCT HANDLING

A. Comply with pertinent provisions of Section 01640.

B. Delivery, storage and handling:

1. Deliver the work of this Section to the job site in such quantities and at such times as to assure the continuity of construction.
2. Store units at the job site in a manner to prevent cracking, distortion, warping, staining and other physical damage, and in a manner to keep markings visible.
3. Lift and support the units only at designated lifting points or supporting points as shown on the approved Shop Drawings.

PART 2 - PRODUCTS

2.1 DESIGN

A. Construct vault according to the dimensions as shown on the plans.

B. Modification:

1. Provide complete design, calculations, and drawings as called for under Article 1.3 above.
2. Maintain the general design concept as shown, without decreasing or increasing sizes of members and without altering profiles and alignment, except as approved by the Engineer.
3. Make necessary provisions in the design to accommodate stress to be encountered.

C. Standards:

1. Design in accordance with pertinent recommendations contained in:
   a. ACI 301.
   b. ACI 304.
   c. ACI 311.
   d. ACI 318.
   e. ACI 347.
   f. CRSI "Manual of Standard Practice".
   g. PCI 116.
2. Comply with requirements of governmental agencies having jurisdiction.
3. In the event of conflict between or among standards, the more stringent provision shall govern unless directed otherwise by the Engineer.

2.2 REINFORCEMENT AND CONNECTION MATERIALS

A. Provide reinforcement, accessories, and connection materials required in accordance with the final design as approved by the Engineer.

B. Standards:

1. Meet or exceed the quality specified for similar materials under other Sections of these Specifications.
2. For materials not specified under other Sections of these Specifications, but required for a complete and proper installation, provide new materials, first quality of their respective kinds, as selected by the Contractor subject to the approval of the Engineer.

2.3 CONCRETE

A. Design strength:

1. Unless otherwise indicated on the Drawings or approved by the Engineer, design the mix and proportion the concrete to attain a minimum compressive strength of 5000 psi when cured and tested at 28 days in accordance with ASTM C 39.
2. Reinforcing steel to meet requirements of ASTM A 615, Grade 60.

2.4 JOINT SEALANT

A. Provide a vulcanized butyl rubber sealant of adequate size and quantity to seal joints in the precast vault risers.

2.5 FABRICATION

A. General:

1. Vault to be monolithically poured.
2. Fabricate the work of this Section to the sizes and shapes indicated.
3. Provide finished units that are straight, true to size and shape, and within the specified casting tolerances.
4. Make exposed edges sharp, straight, and square. Make flat surfaces into a true plane.
5. Warped, cracked, broken, spalled, stained and otherwise defective units will not be acceptable.
6. Place and secure in the forms all anchors, clips, stud bolts, inserts, lifting devices, shear ties, and other devices required for handling and installing the precast units and for attachment of subsequent items as indicated or specified.
7. Cast ladder rungs into the units.
8. Provide tongue and groove joints.
9. Provide polypropylene plastic steps reinforced with 3/8" diameter steel rod, M.S.A. Industries, Inc. Model PS-K or equal.
10. Provide a 1" chamfer edge on all exposed edges above grade.

B. Curing:

1. Form cure the work of this Section for a minimum of 20 hours.
2. Keep wet continuously for not less than six (6) days after being removed from the forms.
3. Following the curing period, allow the units to air dry for at least four (4) days before being shipped.

C. Casting tolerances: Maintain casting, bowing, warping, and dimension tolerances with the following maximums:

1. Overall dimension for height and width of units:
   a. Plus zero of unit dimension to minus 3/32" for 10'0" and over.
2. Make thickness of units ± 1/8" maximum.
3. Bowing or warping: Do not exceed 1/360 of the span.
4. Insert locations: Place within ± 1/4" in each direction.
5. Opening dimensions to figured dimensions:
   a. Accurate within a tolerance of plus 1/8" to minus zero.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 COORDINATION

A. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.

3.3 INSTALLATION

A. Install the work of this Section in strict accordance with the original design, the approved Shop Drawings, pertinent requirements of governmental agencies having jurisdiction, and the manufacturer's recommended installation procedures as approved by the Engineer, anchoring all components firmly into position for long life under hard use.

B. Set bases level so that walls will be plumb.

C. Apply joint sealer or ring gasket to wall section(s), set firmly in place to assure watertight joints.

D. Powder actuated fasteners: Do not use powder actuated fasteners for surface attachment of accessory items except as specifically approved by the Engineer and specifically accepted by the precast unit manufacturer.

3.4 FINISH

A. Comply with pertinent provisions of Section 03300 for cast-in-place concrete.

END OF SECTION

SECTION 11001

SUBMERSIBLE PUMP STATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The work covered by this section consists of all work necessary to furnish and install the pumping station and associated facilities as shown on the drawings and as specified in accordance with the Contract Documents and completely coordinated with work of all other trades.

B. The pump station structure shall consist of the wet well, valve vault, pumps, liftout rails, pump controls and related appurtenances, discharge piping, valves, covered slabs access hatches, and all associated electrical equipment.

C. The CONTRACTOR shall submit to the ENGINEER, shop drawings for all products and components provided under this specification section to be used for the construction of this project.

D. All materials used on this project must have a preliminary inspection by the Inspector before being used for construction purposes. The Owner or Inspector shall rejection any materials that do not meet the specifications and such material shall be immediately removed from the job site.

E. Upon delivery of all products, electrical components, or any other materials, all units shall be delivered, handled, and maintained in appropriate manner to avoid damage. Procedures for protection and use of all products shall be in accordance with the manufacturer's recommendations, specifications and the Contract Documents.

PART 2- PRODUCTS

2.01 STRUCTURES

A. General:

1. The submersible pump station structures shall consist, at a minimum, of wet well, valve vault, and electrical controls. Access hatches for equipment and personnel shall be provided for all structures, and sized appropriately.

B. Wet Well/Structures:

1. The wet well/structures shall be precast concrete manhole sections conforming to ASTM C-478m latest revision. The base for the wet well shall be cast-in-place, steel reinforced concrete. Extended bases or another foundation shall be used to provide adequate bearing surface and flotation protection. The concrete shall have a minimum 28day compressive strength of 4,000-psi.

2. The wet well sections shall have joints of durable mastic sealing material. The joints shall be further waterproofed on the outside of the wet well by the application of asphalt, overlapped by a 12-inch wide band of inorganic asbestos felt, and a finish wrapping of asphalt. The interior side of the joints shall be plastered smooth with 3 coats of Portland cement grout.

3. The wet well shall have a vent made from ductile iron, flanged joint, and pipe fittings as shown on the plans. An insect screen shall be included in one of the pipe fitting joints above the top slab. The insect screen shall be 316 stainless steel.

2.02 MATERIALS AND INSTALLATION

A. Piping:

1. Suction and discharge piping inside the wet well and through the valve vault shall be Pressure Class 350 ductile iron flanged pipe manufactured in conformance with AWWA C153. Flanges and flanged piping shall conform to the requirements of ANSI B16.1, ANSI A21.15 (AWWA C115). Flange bolts shall be minimum ASTM A307, hex-head. A check valve and a gate valve shall be provided for the discharge pipe of each pump, located in a valve vault separate from and adjacent to the wet well.

2. Force main piping shall be solid wall high density polyethylene (HDPE) pipe meeting the requirements of ASTM F714 Polyethylene (PE) Plastic Pipe SDR 11 based on ductile iron size outside diameter, ASTM DI248 and ASTM D3350. The pipe shall be manufactured from high density molecular 3 weight polyethylene resin, which conforms to ASTM DI 248. The pipe produced from this resin shall have a minimum cell classification of 345464C per ASTM D3350.

B. Check Valves:

1. Check valves shall be provided for the discharge line of each pump. Check valves shall be iron body, bronze mounted with resilient faced clapper and outside weight and lever. Check valves shall comply with AWWA C 508, shall have replaceable seat rings of bronze or stainless steel, and shall be manufactured by American, Mueller, or equal. Valves shall be rated for 175-psi working pressure.

2. Valve closure shall be controlled by an external weighted lever arm, the action of which is cushioned by a hydraulic oil or pneumatic cylinder. Counterweights and cushion cylinders shall be designed so that adjustments can be made in the field to minimize surge and to prevent backflow and hammering noises during actual service conditions. The hydraulic oil or pneumatic cushion system shall be completely self-contained.

3. Valve bodies, cover discs, levers, and disc arms shall be constructed of heavy cast iron or cast steel fully conforming to the latest revision of ASTM A-126 Class B or Class WCB, respectively. Valve ends shall be Standard American 125 pound flat-faced flanged, in accordance with ANSI B16.1. Each valve disc shall be suspended from a noncorrosive shaft, which shall pass through a stuffing box and be connected on the outside of the valve to the cushion and counterweight mechanism.

4. Valve seating shall be rubber-to-metal designed for drop-tight shutoff. The body seat ring shall be made of bronze or stainless steel and the disc seat ring of 80 Durometer rubber. Body and disc seats shall be renewable.

5. With the exception of the valve body and seat, all parts in contact with water shall be manufactured from noncorrosive materials. Internal corrosive surfaces shall be shop painted-with two coats of epoxy for corrosion resistance.

6. Check valves shall be manufactured by Mueller, M&H Valve, Henry Pratt Company, or equal.

C. Gauges:

1. Each discharge pipe shall be pressure tapped inside the wet well for a ¼-inch ID fitting. A globe valve and spring-loaded check valve rated to 80 psi shall be threaded into each tap. A ¼-inch ID braid-reinforced PVC tube shall be installed from the check valve to the control panel. The tubing shall be enclosed in 1¼-inch conduit from the wet well wall to the control panel. Two flange-backed, steel-cased, pressure gauges shall be installed on the control panel. The gauges shall be graduated to 60-psi with a minimum 3.5-inch dial face. Plug valves shall be threaded to the gauges and then connected to the tubing.

D. Lift Out Rail System:

1. The lift out systems shall consist of a straight through discharge and rail support elbow that bolts to the bottom of the basin, a combination disconnect assembly with a seal flange that mounts to the pump, rail

support guides that fasten to the wall of the basin in addition to guide and support brackets that mount to the pump. Guide rails shall be Schedule 40 stainless steel pipe. The discharge quick disconnect shall be tapered and have a holding groove machined into the face to hold a sealing O-ring. The tapered seat shall allow the pump to be nearly sealed to the discharge elbow before the sealing faces make contact. A guide plate and adjustable guide bar shall be fastened to top of the pump to insure good alignment and for support of the pump. The rail support and mounting bushing shall be securely mounted to the basin wall and shall not be attached to the basin cover or cover frame. The guide rail support shall be adjustable so that a perfect vertical alignment of the rails can be obtained.

2. Discharge Connection Elbow shall be a straight through fitting with no flap valve and shall be permanently installed in the wet well along with the discharge piping. The pumps shall be automatically connected to the discharge connection elbow when lowered into place. A sliding guide bracket shall be guided by one or two guide bars. The entire weight of the pump shall bear upon the guides and base support with no part of the pump bearing directly on the floor of the sump. A stainless steel wire rope fabricated into 8-fi sections connected together with stainless steel O-rings shall be provided for lifting each pump from the wet well.

3. All hardware used shall be 31 6 stainless steel.

2.03 ELECTRICAL AND PUMP MOTOR CONTROL SPECIFICATIONS

A. General:

1. Electrical service to the pump station shall be three phase, four wire, 480-VAC. The electrical power entrance shall be through a meter base, followed by a NEMA 3R heavy-duty, single throw, fusible safety switch with a solid neutral. All of these electrical components shall be suitably sized to be capable of service with both sewage pumps running. Electrical equipment inside the wet well shall meet the requirements for Class I, Division I, Group C/D service.

2. All electrical components, including the monitor, dialer and the pump control panel, shall be mounted under aluminum weatherhood on an aluminum back panel as specified in the Contract Documents.

B. Alarm Dialer: Cellular Based Station Monitor and Dialer:

1. General:

a. The pumping station shall include a telephone monitoring system furnished and commissioned by the pump supplier to provide single-source responsibility.

b. The system shall be a Crystal Ball™ Series as manufactured by Omni-Site, Inc. and supplied by Pete Duty and Associates, Inc. (803) 276-3211.
c. Unit to be mounted and interconnected inside the pump controller.

2. Programming:

a. The device shall be configured, programmed, and setup using any standard Internet web browser software.
b. All connected equipment can be monitored and configured from anywhere in the world using the world-wide-web.
c. Password protected screens provide secure access.
d. Proprietary programming software or skills shall not be required.

3. Communication:

a. Communication shall be via cellular modem using WINGS protocol.
b. Provide a factory mounted, low profile, secure mount phantom antenna.
c. Inquiry phone calls can be made via a toll free phone number to receive current status report of all alarms and to acknowledge any current alarms.
d. Device shall have capability of being positioned anywhere in the US at any time without coordination with the local or long distance telephone companies.
e. The device shall not incur long distance telephone charges.
f. No landline phone lines or radio propagation studies shall be required, and the contractor SHALL INCLUDE one year of prepaid wireless service in his bid.

3. Alarming and Monitoring:

a. The device shall monitor connected alarms and analyze and report the following information with alarm notifications sent immediately, or at user selectable time delays, and daily time scheduled reports of the following:

1) High water alarm (from level controller).
2) Power failure alarm.
3) Pump 1, 2 Amp Draw.
4) Pump 1, 2 On/Off Cycles.
5) Pump 1, 2 Runtimes.
6) Combined pump runtime.
7) High pump temperature alarm, Pump #1 & #2
8) Cellular signal strength
9) Historical log showing alarm history
10) Graphing of historical data exportable to Microsoft Word or Excel.
11) Crew on-site notification alert.

12) Low battery back-up alarm.
13) Station enclosure low temperature.
14) Independent high water float switch.
15) Six additional alarm inputs.
16) Two additional relay inputs.

b. Alarm notification: Operator programmable using voice call, pager or email.

c. Contact List: Operator programmable, upon alarm activation, the system shall selectively contact the configured recipient list according to the current alarm(s).

5. Power Supply:

a. Incoming electrical service shall be 115 VAC, 60 Hz, single-phase power.
b. Fuse protected 12 VDC power supply shall be powered from the 120-volt incoming power and shall include tapered charge type battery circuitry to maximize battery life. The power supply shall be rated at minimum 2.0 Amps @ 12 VDC.
c. Provide 12-volt battery charging power supply and battery backup with a 36-hour minimum operation time.

6. Protection:

a. Single-phase lightning arrestor connected to each line of the incoming side of the power input terminals. Alarm contacts shall utilize transient protectors, 4000-volt optical isolators. The installing contractor shall provide a good electrical ground connection point.

C. Wire all monitoring /SCADA outputs to terminal strips.

1. Pump station monitoring and control equipment shall be located above finished grade within twenty (20) feet of the wet well for submersible pumps. An aluminum weather hood with a clear height of 74, an overhang of at least 4ft, and a thickness of 3/16-inch, shall be provided for control equipment exposed to the weather. The back panel and side panel shall also be 3/16-inch thick aluminum. The support structure for the weather hood shall be made from structural steel members assembled to provide individual, direct support to the control equipment panel, transfer switch, safety switches, meter base, and the weather hood. The steel frame shall be painted with a two component, high build epoxy polyamide paint system designed for severe service. A junction box shall be provided for power and control wiring to each pump. The junction box shall be located on top of the wet well slab. Submersible pump power and control cables shall be run in conduit through the slab, into the junction box, and shall terminate in the box with power and control wiring to the pump station electrical panel.

D. NEMA 3R Enclosure:

1. The Control Equipment Enclosure shall be a NEMA type 3R and be of suitable size to house all components. A locking hasp shall be provided in addition to screw clamp type latches. Enclosure shall be fabricated from 14-gauge type 316 stainless steel. The top of the enclosure shall serve as a drip shield and the seam free sides shall prevent rain and sleet from entering. Inner panel shall be made of 12-gauge type 316 stainless steel.

E. Hinged Inner Door:

1. An inner door shall be furnished. Overload reset push buttons, circuit breakers, switches, and pilot lights shall be the only components accessible with door closed. Door shall be hinged and may be opened when service is required.

F. Line Terminal Block:

1. A terminal block shall be furnished with properly sized line lugs to accept the main power source entering the control panel. Load lugs shall be adequate to accept all required load side wiring requirements. All live parts shall be fully shielded.

G. Motor Circuit Breaker (440-480 VAC):

1. A properly sized, molded case, hydraulic-magnetic circuit breaker shall be provided for each pump motor. Line and load sides shall be equipped with lugs properly sized for the horsepower and current rating of the motor(s). The interrupting rating shall be 22,000 RMS symmetrical amps.

H. Transformer Primary Circuit Breaker:

1. A properly sized, two pole, molded case circuit breaker shall be furnished ahead of the control power 120-VAC power transformer for short circuit protection and disconnecting power to the transformer. The circuit breaker shall conform to the specifications for the motor circuit breaker(s).

I. Control Power Transformer:

1. An industrial quality control transformer shall be furnished to provide control voltage. The transformer shall be furnished to provide adequate KVA rating to provide 120-VAC power for all items required in the control and alarm circuits. Transformer shall be protected in its secondary by properly sized fuse and/or circuit breaker(s).

J. Solid-state Motor Starters and Overload Relays:

1. Solid-state motor starters: provide a solid-state reduced voltage motor starter for each motor furnished. Contactor and overload relay shall be properly sized for the required horsepower, voltage, and phase.

2. Overload relay: Provide three phase, solid-state overload relays for trip current, phase loss, and phase unbalance protection with a power LED indication. Standard trip contacts in the normally closed position shall be used and shall have trip free operation, visible trip indication and test function. The overload relay shall have electronics that are self protected and harmonic and ambient insensitive.

K. Elapsed Time Meters:

1. Six digit, non-resettable elapsed time meters shall be mounted in the control panel enclosure to record the running time of each pump.

L. Condensation Strip Heater with Thermostat:

1. A strip heater shall be furnished to prevent condensation within the control panel enclosure. The heater shall be controlled by a panel mounted, adjustable thermostat.

M. Phase & Voltage Monitor:

1. A phase failure, reversal and under voltage monitor shall be supplied to prevent the motors from running under low voltage, phase loss, or phase reversal conditions. The monitor shall lock out the control circuit until the problem is corrected and automatically reset.

N. Lightning Arrestor:

1. Suitable lightning arrestors shalt be provided to protect motors and control equipment from lightning induced line surges.

O. Thru - Door Overload Reset Push Buttons:

1. Overload reset push buttons shall be provided for each overload relay. Push buttons shall be mounted so that with inner door closed, overload relays may be reset without entering high voltage compartment.

P. Switches:

1. Heavy-duty industrial grade oil-tight switches shall be provided for each pump for "Hand/Off/Automatic" operation selection. All switch components shall be made of corrosion resistant metals and polyesters. Contact blocks

shall be made of see-through polycarbonate for simplified inspection of contacts. Cams and strokers shall be Teflon impregnated for abrasion free service without lubrication. The switches required shall be as follows:

Switch Function (Name Plate)	Voltage
HOA	120 VAC

Q. Pilot Lights:

1. Full voltage heavy-duty industrial grade oil-tight pilot lights shall be provided. All pilot light components shall be made of corrosion resistant metals and polyesters. An insulated socket shall be furnished to eliminate the possibility of shock during bulb change. Lens shall be made of lexan. The pilot lights required shall be as follows:

Pilot Light Function	Voltage	Lens Color
PUMP 1	120 VAC	GREEN
PUMP 2	120 VAC	GREEN

R. Seal Fail Alarm Circuit with Test Push Button (Required For Submersible Pumps and Motors):

1. The control panel shall be equipped with a conductance actuated control relay that shall respond to current from a moisture sensor in the pump seal chamber. Relay contacts shall be rated at 16 amps minimum. All molded structural parts shall be of high mechanical and dielectric strength, structural dimensionally stable, arc resistant, and thermosetting plastic. Base plate shall be high strength, diecast aluminum alloy. Solidstate type relays shall not be considered acceptable for seal fail monitoring applications. An amber alarm pilot light shall illuminate upon alarm condition. Each pilot light shall include contacts that shall allow testing of the seal failure circuit and pilot light bulb by pushing.

S. Seal Failure Circuit Test Push Button (Illuminated):

1. Heavy-duty industrial grade oil-tight push buttons shall be-provided for each submersible pump motor. All push button components shall be made of corrosion resistant metals and polyesters. Contact blocks shall be made of see-through polycarbonate for simplified inspection of contacts. An insulated socket shall be furnished to eliminate the possibility of shock during bulb change. Lens shall be made of lexan. The push buttons required shall be as follows:

Push Button Function	Voltage	Lens Color
P1 SEAL FAIL	120 VAC	AMBER
P2 SEAL FAIL	120 VAC	AMBER

T. Pump Alternator Circuit (For Duplex Pump Operation):

1. The electro-mechanical alternator relay shall be of industrial design specifically for use in pump applications. It shall have single-pole double-throw heavyduty 10-amp silver cadmium oxide contacts enclosed in a transparent cover. The snap action contacts shall transfer when the unit is deenergized. The circuit shall never be closed or opened while current is being conducted. The alternator circuit shall alternate the lead pump position between the pumps and shall allow the lag pump to start in response to a rising water level in the wet well.

U. Control Relay(s):

1. Plug-in control relays with 120-VAC coils shall be provided as required. Contact rating shall be 5-amps (minimum). Sockets shall be of the same manufacture as the relays and holddown clips shall be furnished to prevent relay form sliding out of the socket.

V. High Wet Well Level Alarm:

1. The control panel shall be provided with a suitable alarm circuit, activated by a separate level control. This alarm shall signal a high water condition in the wet well. Terminals shall be furnished in the control panel for connection of an externally mounted alarm device. A red flashing light shall be provided as a visual alarm of the high water in the wet well condition.

W. Low Wet Well Level Alarm:

1. The control panel shall be provided with a suitable alarm circuit, activated by a separate level control. This alarm shall signal a low water condition in the wet well. Terminals shall be furnished in the control panel for connection of an externally mounted alarm device. A red flashing light shall be provided as a visual alarm of the low water in the wet well condition.

X. Liquid Level Controls:

1. Float-actuated micro-switch level control shall be provided for: pumps off, lead pump on, lag pump on, and high-level alarm functions. The mercury switch shall be encapsulated in polyurethane foam for corrosion and shock resistance. Level switches shall be weighted to hold desired position in the sump. The cord connection to the control shall be numbered 16-2, rated for 13-amps, and shall be type SJTO. To ensure optimum longevity contacts shall be rated for 20-amps at 115-VAC and

shall be sealed in a heavy-duty glass enclosure. No junction boxes or cable splices of any kind will be allowed in the wet well.

2. Provide intrinsically safe relays for level switches in the control panel.

Y. High Temperature Shutdown Circuit(s):

1. The pump motor high temperature circuit shall provide terminals for connection of the leads from the temperature sensor provided in the pump motor windings. Upon a high temperature condition in the pump windings, the control power to the pump motor contactor shall be disconnected, thus stopping the pump motor. The pump shall automatically restart when the pump motor temperature returns to an acceptable level.

Z. Ground Lug(s):

1. Equipment ground lug(s) shall be provided for grounding the enclosure. The ground lug(s) shall be suitable for the service provided the enclosure sized per table 250-95 of the N.E.C. In all cases, the enclosure must be adequately grounded per article 250 of the N.E.C.

AA. Terminals:

1. Terminals shall be provided for connecting micro-switch floats leads, temperature sensor, and seal fail sensor leads. Terminal blocks shall be rated for 600 volt use and accept a wire range of #22-8. All live parts shall have insulating walls on all sides of the lug. Blocks must be U.S. recognized.

BB. Monitoring and Remote Control Requirements:

1. Design pump station control panel to provide remote Start/Stop control of pumps via future SCADA RTU. Install jumpers on pilot device terminals.

2. For each motor, provide the following dry contact outputs:

   a. Motor running
   b. Motor fault
   c. Moisture in stator chamber

3. Provide additional outputs for the following:

   a. High well level
   b. Loss of power

4. Completely wire all outputs to monitoring /SCADA terminal strips.

CC. Construction Standards:

1. Subpanel shall be drilled and tapped to accept machine thread bolts (self tapping screws are not acceptable). All control wiring shall be 16-AWC machine tool wire, Carol type 7651 2 or equal. All control wire shall be color coded or numbered in accordance with the standards. Power (motor) shall be in accordance with the 1984 National Electrical Code. Major groups of wires shall be contained in plastic wiring trough equal to Panduit type E.

DD. Nameplates:

1. All indicator lights, alarms, selector switches, pushbuttons and major control system components shall be identified with engraved phenolic plastic nameplates, white lettering on a black background.

EE. Guarantee:

1. The manufacturer of the control panel shall furnish a warranty for one year from the date of shipment that all equipment shall be free from defects in design, materials, and workmanship. The control panel manufacturer shall furnish replacement parts for any component proven defective, whether of his or other manufacture during the guarantee period, excepting only those items that are normally consumed in service, such as light bulbs.

2.04 PUMPS AND MOTORS

A. Pump and Power Requirements:

1. The pumps shall be manufactured by Flygt, ABS, Fairbanks-Morse, or approved equal. The pumps shall operate at 1000 gpm @ 92 feet TDH, requiring 34 BHP at the system operating point on the pump curve.

2. Pumps shall be submersible, non-clog centrifugal wastewater pumps capable of passing a three (3) inch sphere. Submersible pumps shall be capable of handling raw, unscreened wastewater. Major pump components shall be of gray cast iron devoid of burrs, pits, or other irregularities.

B. Pump Motors:

1. The pump motors shall be sealed submersible type, and shall be three phase, 60 Hertz, 480v motors with a maximum speed of 1800 RPM, 50 HP maximum. The motors shall meet the U.S. requirements of Class I,

Division I, Group D for hazardous locations and shall be sized to non-overloading throughout the entire operating range of the pump.

2. Stator winding shall be of the open type with insulation good for 180°C maximum temperature. Winding housing shall be air filled or otherwise filled with clean high dielectric oil that lubricates bearings and seals and transfer heat from windings and rotor to outer shell.

3. Motor shall have two (2) heavy-duty ball bearings to support pump shaft and take radial and thrust loads and a sleeve guide bushing directly above the lower seal to take radial load and act as flame path for seal chamber. Ball bearings shall be designed for 40,000 hours B-10 life. Stator shall be heat shrunk into motor housing.

4. A heated sensor thermostat shall be attached to and embedded in the winding and be connected in series with the motor starter contactor coil to stop motor if temperature of winding is more than 220°F. Thermostat shall reset automatically when motor cools to safe operating temperature. The common pump motor shaft shall be of 41 6 stainless steel.

5. The pump motor shall be protected by two (2) mechanical seals mounted in tandem with a seal chamber between the seals. Seal chamber shall be oil filled to lubricate seal face and to transmit heat from shaft to outer shell. Seal face shall be carbon and ceramic and lapped to a tolerance of one light band. Lower seal faces shall be tungsten or silicon carbide.

6. A double electrode shall be mounted in the seal chamber to detect any water entering the chamber through the lower seal. Water in the chamber shall cause a red light to turn on at the control panel. This signal shall not stop the motor but shall act as a warning only.

7. Power cables to pumps shall be AWG (min) hypalon jacketed type SPC cable a minimum of forty (40) feet in length.

PART 3- TESTING, WARRANTIES, AND PAYMENT

3.01 TESTING

A. At the time of start-up, the manufacturer-supplied start-up forms shall be completely filled out and transmitted to the ENGINEER. The final tests shall include but not be limited to rotation, pumping head, amperage reading, wiring insulation resistance, water tightness, voltages, check valve operation and grinder operation.

3.02 WARRANTIES

A. The pump manufacturer shall warrant to the OWNER that the pumps, grinders, motors, and controls supplied are free of defects in workmanship and materials for a period of one (1) year. The warranty shall be in printed form and made applicable to the OWNER (as Warrantee) at the time of acceptance for maintenance by the OWNER.

3.03 SERVICES OF MANUFACTURERS' REPRESENTATIVE

A. Equipment, when furnished, shall include the cost of a competent representative of the manufacturers of all equipment to supervise the installation, adjustment, and testing of the equipment and to instruct the Owner's operating personnel on operation and maintenance.

B. This supervision may be divided into two or more time periods as required by the installation program or as directed by the Engineer.

C. See the detailed Specifications for additional requirements for furnishing the services of manufacturer's representatives.

3.04 OPERATING MANUALS

A. Six complete sets of operation and maintenance instructions covering all equipment furnished shall be delivered to the Engineer.

B. The manual for each piece of equipment shall be a separate document with the following specific requirements:

1. Contents:

   a. Table of contents and index
   b. Brief description of each system and components
   c. Starting and stopping procedures
   d. Special operating instructions
   e. Routine maintenance procedures
   f. Manufacturer's printed operating and maintenance instructions, parts list, illustrations, and diagrams
   g. One copy of each wiring diagram
   h. One copy of each approved shop drawing and each Contractor's coordination and layout drawing
   i. List of spare parts, manufacturer's price, and recommended quantity
   j. Name, address and telephone numbers of local service representatives.

2. Material:

   a. Loose leaf on 60 pound, punched paper
   b. Holes reinforced with plastic cloth or metal
   c. Diagrams, illustrations, and attached foldouts as required, of original quality, reproduced by dry copy method

d. Covers: oil, moisture and wear resistant 9 x 12 size

3. Submittals to the Engineer:

   a. Three preliminary copies of manuals shall be submitted to the Engineer no later than 15 days following approval of the shop drawings for each piece of equipment.

   b. Provide six final copies of complete manuals prior to testing.

C. Contents of each Volume:

1. Table of Contents: Provide title of Project, names, addresses, and telephone numbers of Engineer, subconsultants, and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.

2. For Each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers; including local source of supplies and replacement parts.

3. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.

4. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams. Do not use Project Record Documents as maintenance drawings.

5. Type Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified.

D. Manual for Equipment and Systems:

1. For each Item of Equipment and Each System provide the following:

   a. Overview of System and description of unit or system, and component parts.
   b. Identify function, normal operating characteristics and limiting conditions.
   c. Include performance curves, with engineering data and tests and complete nomenclature and commercial number of replaceable parts.
   d. Panelboard Circuit Directories including electrical service characteristics, controls and communications, and color-coded wiring diagrams as installed.
   e. Operating Procedures: include start-up, break-in, and routine normal operating instructions and sequences; regulation, control, stopping,

shutdown, and emergency instructions; and summer, winter, and any special operating instructions.

E. Maintenance Requirements:

1. Routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.

2. Servicing and lubrication schedule and list of lubricants required.

3. Manufacturer's printed operation and maintenance instructions.

4. Sequence of operation by controls manufacturer.

5. Original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.

6. Control diagrams by controls manufacturer as installed.

7. Contractor's coordination drawings, with color coded piping diagrams as installed.

8. Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.

9. List of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.

10. Test and balancing reports as specified.

F. Instructions of Owner Personnel:

1. Before final inspection, fully instruct Owner's designated operating and maintenance personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon time.

2. The Contractor shall have instructions video taped while they are being given to Owner's personnel.

3. A person shall perform videotaping or organization experienced in the production of tapes and shall include the entire instruction session(s) and all questions and answers.

4. Two (2) tapes (one original and one copy) shall become the property of the Owner.

5. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

6. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

END OF SECTION

SECTION 11294

AIR RELEASE AND VACUUM VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included: Provide air release and vacuum valves at all locations indicated on the Drawings, and as specified herein, complete and ready for operation.

B. Related work: Documents affecting work of this Section include, but are not necessarily limited to, Contract Drawings and details therein, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Referenced manufacturer is Crispin and is named to establish standards of quality. Equal products of other manufacturers conforming to these specifications, and as outlined in the bid form may be provided upon approval by the Engineer.

C. Manufacturers to have a minimum of ten (10) years operating experience for the specified valve style.

D. Provide valves with castings and all other components manufactured in the United States.

1. Foreign made components may be provided if manufacturer meets ISO 9000 requirements.
2. Perform final assembly and testing at the manufacturer's factory located in the United States.

1.3 SUBMITTALS

A. Comply with pertinent provisions of Section 01340.

B. Product data: Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:

1. Materials list of items proposed to be provided under this Section.
    a. Provide listing of all valves to be provided and include type of valve and location.
2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
3. Shop drawings showing sectional views, dimensions, end connections, and operator details.

C. Provide Maintenance manuals complying with provisions of Section 01650.

1.4 PRODUCT HANDLING

A. Comply with pertinent provisions of Section 01640.

1.5 WARRANTY

A. Provide a standard two-year warranty on all labor and materials.

B. The warranty will begin upon successful completion of the initial operating period.

PART 2 - PRODUCTS

2.1 AIR RELEASE AND VACUUM VALVES

A. Provide single body universal type with compound lever system.

1. Design valve to automatically exhaust large amounts of air and gases while the pipeline or system is being filled.
2. Design valve to release accumulated pockets of air while the pipeline is in operation.
3. Design valve to re-open to admit air during draining or when a negative pressure exists in the system.

B. Provide an interchangeable drop-in head assembly for easy cleaning. Valves requiring on-site backwashing are not acceptable.

C. Provide the valve body and interchangeable drop-in head assembly of cast or fabricated 316-stainless steel.

1. Incorporate a "sanitary clamp" to attach the head assembly to the body at the outlet.
2. Valves that use bolting to attach the cover flange to the body

are not acceptable.

3. Locate the flange clamp at the outlet of the body for ease of cleaning and maintenance.
   1. Other clamping locations are not acceptable.

D. All non-sealing internal metal components shall be 316-stainless steel; plastic, nylon, or fiberglass components will not be acceptable.

Component	Material	Specification
Body & Cover Flange	316 stainless steel	ASTM A240
Float	316 stainless steel	ASTM A240
Internal Trim	316 stainless steel	ASTM A240
Seat	Rubber	Buna-N
Bolting-Sanitary Clamp	316 stainless steel	ASTM A240

E. Provide valve with minimum 2" inlet, or larger, if shown on the drawings.

F. Provide air and vacuum valves of the size listed in the schedule or shown on the plans with threaded inlet and outlet to 3" size and ANSI B16.1 Class 125 flanged inlet and threaded outlet in larger sizes.

G. Incorporate an air release orifice of 3/16" for use at 200 psi.

1. No deviation from this orifice size will be allowed.
2. Locate in the outlet of the valve and drill in a 316 stainless steel orifice plate that seals against a Buna-N rubber seat.
3. Valves with seals that flex or roll will not be acceptable.

H. Provide protective cover to prevent debris from falling into release orifice.

I. Provide inlet Type 316 stainless steel ball valve with T-handle operator.

J. All piping, nipples, etc., to be Schedule 40, Type 316L stainless steel.

K. Valves to be a maximum 14 inches in overall height and maximum weight of 25 lbs.

L. Provide one spare drop-in head assembly for every five (5) valves.

M. Provide Crispin "X" Series, Model UX20.

P. Air release and vacuum valve manhole:

1. Provide reinforced precast concrete ring and flat top slab section complying with ASTM C-478 and the following.
2. Use portland cement complying with ASTM C-150, Type II.
3. Cast base slab monolithically with walls.
4. Design flat slab top sections for HS-20 traffic loadings.
5. Provide tongue and groove with vulcanized butyl rubber sealant or "O" ring rubber gasketed joints.
6. Cast or factory cut pipe opening in manholes:
   a. Provide flexible pipe boot conforming to ASTM C-923M.
   b. Attach boot to piping with dual stainless steel straps.
   c. All other hardware to be stainless steel.
   d. Provide Kor-N-Seal or equal.
7. Size lift holes and inserts for a precision fit with the lift devices.
   a. Holes shall not penetrate through the manhole wall.
   b. Comply with OSHA Standard 1926.704.
8. Provide flat slab tops.

9. Steps:
   a. Provide polypropylene plastic steps reinforced with "3/8" " diameter steel rod, M.S.A. Industries, Inc. Model PS-K, or equal.
   b. Provide steps having non-skid top surfaces, safety slope at each end, minimum width of 10" and not less than 5" projection from wall.
   c. Embed a minimum of 3".
   d. Maximum spacing - 16".
10. Frames and covers:
    a. Provide gray iron castings, complying with ASTM A 48, Class 35B iron and AASHTO M-306.
    b. Provide a minimum recycled material content of 75 consisting of post-consumer material.
    c. Castings shall be of uniform quality, free from sand holes, gas holes, shrinkage, cracks and other surface defects ground smooth and clean by shot blasting.
    d. Cast or machine bearing surfaces between rings and covers with such precision to prevent rocking.
    e. Casting dimensional tolerances shall be +/- 1/16" per foot.
    f. Conduct a first article proof load test and make the results of that proof load available upon request.
       i. Conduct in accordance with the method and procedure outlined in AASHTO M-306.

ii. Test casting on a suitable and calibrated load testing machine. Casting shall hold a 40,000 pound proof load for one minute without experiencing any cracks or detrimental permanent deformation.

iii. Maintain test results for each lot of castings by the foundry for a minimum of seven years. Make available upon request.

g. Provide inspections in accordance with AASHTO M-306 and furnish results of these tests upon request.

h. Furnish a foundry certification stating that samples representing each lot have been tested, inspected, and are in accordance with this specification.

i. Each casting shall be identifiable and show, at a minimum, the following: name of the producing foundry, country of manufacturer, ASTM material designation, recycle symbol, individual part number, cast or heat date.

j. Provide frame weighing not less than 155 lbs. with inside opening between 21.8" and 24".

k. Provide circular cover with two "pick" holes, one 1" diameter vent hole, and weighing not less than 130 lbs.

l. Provide East Jordan Iron Works, Inc. Model V-1384 or approved equal.

2.2 SERVICE SADDLE

A. Provide of the following materials:

Body	Type 304 Stainless Steel
Bales and Strips	Type 304 Stainless Steel
Studs	Type 304 Stainless Steel
Hardware	Type 304 Stainless Steel

B. Provide double-strap for sizes 5" and larger.

C. Provide Romac 304 and 305 or approved equal.

D. Connect to pipeline using a 6" stainless steel nipple.

1. Do not use a threaded PVC connection.

PART 3 - EXECUTION

3.1 GENERAL

A. Handle, store and install all valves complying with the manufacturer's recommendations and the Drawings.

B. Valves installed in horizontal pipe runs shall be mounted with the plug horizontal and at the top of the body when the valve is open.

3.2 PAINTING

A. Exposed valves:

1. Factory painting:
   a. Sandblast to SSPC-10 Near White Metal.
   b. Prime exterior with Tnemec 66-1211 Epoxoline Primer, 3.0 dry mils.
   c. Paint interior of valve with two coats of coal tar epoxy, TNEMEC Hi-Build Tneme-Tar, minimum 14 mils dry thickness.

B. Buried valves:

1. Sandblast to SSPC-10 Near White metal.
2. Paint exterior and interior of valve with two coats of coal tar epoxy, TNEMEC Hi-Build Tneme-Tar, minimum 14 mils dry thickness.

END OF SECTION

ATTACHMENT 2

CLOSURE PLAN ADDENDUM

The purpose of this document is to supplement the Wateree Station Class Three Landfill Closure Plan (as presented in the solid waste permit application document, prepared November 2012 and SCDHEC-approved January 2013, permit # LF3-00026) to provide a discussion on how the Closure Plan's final cover system achieves the performance standards specified in CCR rule §257.102 (d). This document serves as an Addendum Supplement to the Closure Plan.

A. FINAL COVER PERFORMANCE STANDARDS

CCR rule §257.102 (d) states:

> (d) Closure performance standard when leaving CCR in place. (1) The owner or operator of a CCR unit must ensure that, at a minimum, the CCR unit is closed in a manner that will:
>
> (i) Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;
>
> (ii) Preclude the probability of future impoundment of water, sediment, or slurry;
>
> (iii) Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;
>
> (iv) Minimize the need for further maintenance of the CCR unit; and
>
> (v) Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

The following sections provide discussions how the final cover system will achieve the performance standards specified above.

B. CCR rule §257.102 (d)(i)

The Closure Plan includes a lined final cover system designed to minimize the infiltration of liquids into the waste. The final cover system includes a synthetic geomembrane liner and overlying drainage and collection layer designed to convey stormwater runoff from the landfill surface and prevent head built-up on the liner. The construction quality assurance (CQA) technical specifications included by reference in the Closure Plan provide description of the materials to be used in the final cover system and the methods and procedures required to install the final cover system. Adherence to these specifications including material selection and testing protocols, as required by the facility's permit, will ensure that the final cover is installed using appropriate materials and methods to provide a final cover that will minimize and/or eliminate infiltration of liquids into the waste.

The landfill final grades shall not be less than 3% to promote positive drainage and prevent ponding, thereby promoting surface runoff and minimizing and/or eliminating infiltration through the final cover and into the waste. Additionally, based on the nature of the waste material, differential settlement of the waste mass is not expected and therefore no isolated depressions that could hold water (and promote infiltration) are anticipated.

With infiltration of liquids into the waste minimized and/or eliminated as discussed above, the release of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere is not anticipated.

C. CCR rule §257.102 (d)(ii)

The final cover grading plans included by reference in the Closure Plan provide for final cover grades ranging from a minimum 3% (to prevent ponding) and no greater than 25% (to minimize erosion). Based on the nature of the waste material, differential settlement of the waste mass is also not expected and no isolated depressions of standing waters are anticipated. As such, the Closure Plan provide for positive runoff from the closed landfill surface and thereby precludes the probability of future impoundment of water and stormwater runoff sediment on the landfill.

Further, the landfill receives only dry handled CCR materials which are transported to the landfill in dumptrucks. There is no infrastructure or other means in-place that could allow for the future impoundment of slurry in or on the landfill.

D. CCR rule §257.102 (d)(iii)

The final cover drawings and CQA technical specifications included by reference in the Closure Plan were designed consistent with the results of global and final cover veneer stability engineering analyses performed for the landfill facility (as presented in the solid waste permit application document, prepared November 2012 and SCDHEC-approved January 2013, permit # LF3-00026). The engineering analyses demonstrate that the final cover grades and materials are stable. Moreover, the final waste and cover grade slopes are not excessively steep (25%) and include a stormwater management system (terrace berms and downslope stormwater piping) designed to collect and convey stormwater off the final cover to minimize erosion along the slope. Given the final cover system's grades, materials of construction, and stormwater management system, the final cover is anticipated to remain stable, with no sloughing or movement of the final cover system anticipated during the closure and post-closure care period.

E. CCR rule §257.102 (d)(iv)

The final cover grades and details were designed to minimize future maintenance of the landfill facility. The Closure Plan grades and layout provides for a stable waste mass and final cover system, grades

appropriate for the establishment of a good stand of cover grasses, and a surface water collection and conveyance system (terrace berms, downdrain piping network, etc.) designed to manage runoff and prevent erosion. With normal routine maintenance of the final cover (mowing, overseeding, etc.), the closed landfill is not anticipated to require additional maintenance.

F. CCR rule §257.102 (d)(v)

As presented in the Closure Plan, once an area has been determined to be closed, SCE&G will prepare a schedule for closure activities. Closure of the subject area must be completed within 180 days following of beginning closure activities. Extensions of the closure event period may be granted by SCDHEC if, SCE&G demonstrates that closure will take longer than 180 days and they have taken and will continue to take all steps to prevent threats to human health and the environment from the unclosed landfill and complete closure in a timely manner.